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THE UNITED STATES SHIPBUILDING AND SHIP REPAIR INDUSTRY: ADEQUATE FOR PROLONGED GLOBAL CONFLICT?

A thesis presented to the faculty of the
U.S. Army Command and General Staff College
in partial fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

ROBERT MARTIN BROWN, LIEUTENANT COMMANDER, U.S. NAVY
B.A., University of Colorado, 1978

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This thesis examines the ability of the American shipbuilding and ship repair industry to meet the national defense requirements of a prolonged global war involving the United States.

A history of this vitally important industry is presented to illustrate the problems that have plagued it for over a century. In addition, the key role played by shipyards in the outcome of the last global conflict, World War II, is examined.

Estimated wartime demands to be placed on shipyards are detailed and compared to the three integral parts of the industry: physical plant, skilled labor, and equipment suppliers. Based on this analysis, conclusions are made concerning the adequacy of U.S. shipyards in time of war. The study concludes

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Possible solutions to this industrial readiness problem are also presented and discussed.

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DEDICATION

This thesis is dedicated to the memory of COMMANDER DONALD N. BROWN: Naval Aviator, Father, and the finest man I have ever known.

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I owe a great debt of gratitude to three groups of people involved in the completion of this thesis.

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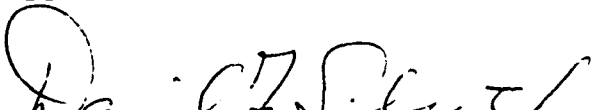

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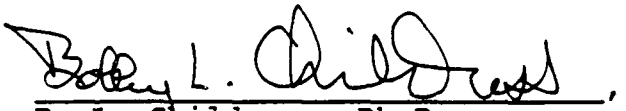

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other government agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE UNITED STATES SHIPBUILDING AND SHIP REPAIR INDUSTRY: ADEQUATE FOR PROLONGED GLOBAL CONFLICT? By LCDR Robert M. Brown, U.S. Navy, 177 pages.

This thesis examines the ability of the American shipbuilding and ship repair industry to meet the national defense requirements of a prolonged global war involving the United States.

A history of this vitally important industry is presented to illustrate the problems that have plagued it for over a century. In addition, the key role played by shipyards in the outcome of the last global conflict, World War II, is examined.

Estimated wartime demands to be placed on shipyards are detailed and compared to the three integral parts of the industry: physical plant, skilled labor, and equipment suppliers. Based on this analysis, conclusions are made concerning the adequacy of U.S. shipyards in time of war. The study concludes numerous shortfalls would be encountered in the reactivation, repair, and construction of merchant and naval vessels; this poses serious questions concerning the ability of this country to sustain forces in a prolonged conflict.

Possible solutions to this industrial readiness problem are also presented and discussed.

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CHAPTER 1

INTRODUCTION

Background

Since the dawn of the industrial age in the nineteenth century, an integral part of a nation's ability to wage war has been the effective mobilization of its industries to war production. In large-scale conflicts, such as World War II, virtually all United States industries, from food to textiles to automobiles, were reconfigured with the main goal of supporting the fighting forces in the field. In no area was this more crucial than in the shipbuilding and repair industry. As is true today, the United States was indeed an "island nation" with respect to its most important overseas commitments. The ability of the U.S. to build and repair huge numbers of ships to fight and carry the supplies of the "Arsenal of Democracy" around the world was pivotal to the allied victory in World War II. The credit for this great accomplishment belonged to both the public and private sectors. For then as now, the United States shipbuilding and ship repair industry was comprised of both U.S. Navy and civilian shipyards. The U.S. Naval Shipyards concentrated on the construction and repair of Navy combatant ships, and civilian shipyards built thousands of cargo, tanker, and Naval supply ships that kept open the sea lifelines to our allies.

In the decades since the end of World War II, the size of the U.S. Naval shipyard base has remained relatively constant, in spite of the fact that these shipyards now only perform repair work. However, the civilian maritime industries of the U.S., including the shipbuilders, have been in steady decline for forty years. At the end of 1987, for the first time in this nation's history, no commercial ocean-going vessels were being built in U.S. shipyards.(1) This collapse has effected not only the shipbuilders, but also their thousands of suppliers and subcontractors. This situation has come about for a number of economic reasons: a recession in the world shipping market, a worldwide overcapacity in shipbuilding assets, and the inability of American shipyards to compete with foreign shipyards. In a peacetime environment, the argument can be made that this decline is but another example of the transition of the American economy from a manufacturing to a service orientation, and that the laws of economics should be allowed to run their course. However, when planning for wartime mobilization, the condition of the U.S. shipbuilding and repair industry must be viewed in an extremely different light. The maintenance of an adequate shipbuilding and repair capability in the U.S. is a cornerstone of defense, and must be preserved regardless of current economic conditions in the industry.

During conflicts of the twentieth century, American ships have carried 95 percent of the men, materiel, and supplies sent to the far-flung battlefields of the world.(2) In spite of changing doctrine and equipment, American resupply in any future conflict will again be dependent upon seaborne transportation. Given the ever-shrinking merchant fleets of the U.S. and its allies, in future conflict, this country will rely immediately and heavily upon American shipbuilders in a number of capacities. First, the reactivation of inactive "mothballed" ships set aside by the government for national emergencies must be accomplished. Second, there must be construction of new merchant and naval vessels to carry war materials. Finally, repair of merchant and naval vessels, in response to battle damage or normal operating wear, must be accomplished expeditiously. This will involve the enlargement and efficient integration of the three key elements of shipbuilding and repair: a large and complex physical plant; an available supply of skilled manpower; and a robust equipment supplier base able to provide the thousands of component parts that make up a ship. Only by combining these three elements to meet these tasks can the U.S. shipbuilding industry make a decisive contribution to American victory in any future prolonged conflict. It is the goal of this thesis to determine if the United States shipbuilding and ship repair industry,

including both U.S. Navy and civilian shipyards, is able to accomplish the tasks.

Assumptions

1. The protracted conflict envisioned is of a global nature, involving hostilities on three fronts.

2. The conflict is of sufficient length to test the country's mobilization capacity.

3. A general mobilization of U.S. industry is ordered by the national government.

4. There is no exchange of strategic nuclear weapons by the belligerents.

Definitions of Terms

1. Active Shipbuilding Industrial Base - U.S. shipyards seeking, as well as having, the capability of constructing naval and/or large merchant vessels.

2. Building Ways (Positions) - Areas of a shipyard designed for the construction or final assemly of a vessel. These include graving docks and side and stern-launched building ways.

3. Cabotage - Reservation of a country's coastal (domestic) shipping for vessels of its own flag registry.

4. Deadweight Tons (DWT) - A vessel's carrying capacity in tons of 2,240 lbs. each.

5. Equipment Suppliers - Those segments of the U.S. manufacturing base providing machinery, equipment, and materials essential to shipbuilding and ship repair.

6. EUSC (Effective U.S. Controlled) Fleet -Those merchant vessels owned by U.S. citizens or corporations but registered under "Flags of Convenience" (usually defined as those of the Bahamas, Panama, Liberia, and Honduras) whose ship registration laws do not interfere with the activities of foreign-owned ships. This term is used to emphasize that, although the EUSC Fleet is not U.S. flag, it is considered to be effectively under U.S. control by virtue of ownership and could be requisitioned by the U.S. government in time of war or national emergencies.(3)

7. Flag of Convenience - The practice of registering merchant ships under flags not those of the owners, in order to obtain such benefits as tax advantages, lower operating costs, and lower construction costs.(4)

8. ISNAC (Inactive Ships in Navy Custody) - Those Navy-owned ships in reserve (the "mothball fleet") for which the Navy retains responsibility for maintenance and preservation.

9. MARAD Mobilization Dry Cargo Ship & Tanker - Proposed standard ship designs developed by the U.S. Maritime Administration for cargo and tanker ships. The intent of these designs is to provide two standardized

blueprints for 700-foot long ships which could be easily mass produced by the U.S. shipbuilding industry in wartime.

10. National Defense Reserve Fleet (NDRF) - Commercial cargo, tanker, and other miscellaneous ships owned by the U.S. Maritime Administration and kept in an inactive status in several layup sites around the United States. In time of war, these ships would be reactivated in 60 or more days by shipyards to provide attrition replacements or economic support service.

11. Overhaul - A regularly scheduled maintenance project designed to significantly or completely refurbish and refit a ship. In the case of a merchant ship, a four to twelve month process every four to six years; for Navy vessels, a four to eighteen month process every four to five years.

12. Prolonged Conflict - A conflict of sufficient length and intensity to move planning past initial "surge" requirements into the sustainment phase of operations (90 days to 48 months after commencement of hostilities.)

13. Ready Reserve Force (RRF) - The most modern NDRF ships. These ships have first priority for reactivation, and are to be ready to sail 5 to 20 days after the reactivation order is received.

14. Ship Manager - A civilian company contracted by the Maritime Administration to perform routine

maintenance and reactivation, if required, on ships of the Ready Reserve Force.

15. Ship Reactivation - The return to active service of deactivated "mothballed" ships currently in a reduced state of material readiness.

16. Ship Repair - The correction of shipboard material deficiencies caused by hostile action or normal operating wear.

17. Shipyard Mobilization Base - U.S. shipyards with suitable physical characteristics (i.e. capable of berthing and repairing vessels greater than 400 feet in length and 12 feet in draft) that could repair, reactivate, and/or construct ships in a war.

18. Skilled Labor - Management personnel and production workers with specific technical skills required for the operation of a shipyard in the construction, reactivation, and repair of ships.

19. "Warm" Industrial Base - The existence of competitive productive peacetime industries available for rapid conversion or expansion in time of war or national emergency.

Limitations

1. Due to the distant locations of major shipyards and government agencies, research interviews were conducted by telephone.

2. Exact numbers of ships to be repaired/constructed was difficult to derive due to the inability to precisely forecast the number of naval/merchant vessels which will be sunk or damaged in a future conflict. As such, government simulations have been cited to provide the most realistic inputs possible to the problem.

Delimitations

1. The availability of selected foreign shipyards to perform some emergency repair work on U.S. ships is assumed, but will not be studied.

2. The ability of the U.S. to tow inactive ships from present locations to activation shipyards without delay will not be examined.

Significance of the Study

In a future global conflict, U.S. planners are depending on an uninterrupted flow of supplies from the United States and its allies to multiple theaters of operations. Included in these supplies would be petroleum, manufactured goods, ammunition, and the myriad products required to sustain forward deployed forces. Due to the bulk involved, the vast majority of these supplies must travel by sea.(5) To meet these needs, the U.S. government would quickly attempt to locate and press into service all U.S. flag merchant ships, and

those foreign flag ships owned by Americans under the "Flag of Convenience" arrangements. The ability to quickly transition the foreign flag ships to maritime service is doubtful, however, especially considering the foreign crews involved. Also, many merchant ships will continue to be required to support U.S. industries and the economy as a whole. The gap between today's maritime assets and tomorrow's national defense requirements must be filled by the nation's shipyards. To support this supply effort, the U.S. shipbuilding/ship repair industry must quickly reactivate, build, and repair sufficient quantities of ships to do the job. If this does not occur, brilliant tactical successes on the battlefield will be for naught, as insufficient logistics will doom theater operations as a whole. Thus, this study has significance to all military planners.

Review of the Literature

Given the number of government agencies and industry groups directly or indirectly involved with the maritime industries, a fairly large body of literature was available. For purposes of analysis, the literature was broken down into six main categories: books, government documents and studies, periodical articles, studies by individuals and private industry, transcripts of congressional testimony and seminars, and interviews and correspondence conducted with U.S. government and

industry officials involved with monitoring the shipbuilding/ship repair industry.

Books

John Ellison's Mobilizing U.S. Industry: A Vanishing Option for National Security, provides an excellent overview of the huge demands that will be placed on United States industry in a future large-scale conflict. Studied in concert with Roderick Vawter's Industrial Mobilization: The Relevant History, the reader is presented with two major points relevant to this thesis. First, the twentieth century wartime accomplishments of mobilized American industry have been inspiring. Secondly, the American industrial base (including shipbuilding) has changed drastically in the years since the last full-scale mobilization.

America's Maritime Legacy: A History of the U.S. Merchant Marine and Shipbuilding Industry Since Colonial Times, by Robert A. Kilmarx, is a concise, 350-year chronicle of the cyclical nature of the American shipbuilding and repair industry. Among other topics, he deals with the "Golden Age" of American shipbuilding, periods of industry decline, and the expansion of the industry during World Wars I and II. This final subject provides valuable insight into past problems encountered with massive shipyard mobilization.

The U.S. Shipbuilding Industry: Past, Present, and Future, by Clinton Whitehurst, is an excellent

treatment of the shipbuilding industry. The book consists of a history of shipbuilding, as well as detailed descriptions of the physical plant and worker pool comprising the modern industry. Also discussed in detail is the broad array of support mechanisms established by the U.S. government to foster a healthy shipbuilding and repair industry.

Immediately after the end of World War II, Donald Nelson, a senior official in the War Production Board, authored Arsenal of Democracy. This book provides a glimpse inside the massive shipyard mobilization of World War II, its accomplishments, difficulties, and the efforts of the federal government in ensuring its eventual success.

Government Documents and Studies

Numerous studies have been conducted by government agencies in the last five years aimed at examining the state of the shipbuilding and repair industry, its ability to support wartime mobilization efforts, and the government aid required to sustain a viable mobilization base. The most significant of these reports are described below.

Shipping, Shipyards, and Sealift: Issues of National Security and Federal Support (1983), was prepared by the National Advisory Committee on Oceans and Atmosphere. The report provides an excellent history of government support to U.S. shipyards. The report states

that shipyard assets would be sufficient in time of war. However, the report based its analysis on the assumption that a future major conflict would be short in duration, and only ship reactivation and repair activity would be of critical importance. The report also assumed the ready availability of skilled labor and component equipment for any required wartime construction. As such, the report advocated more emphasis on aid to the active U.S. Merchant Marine, as opposed to U.S. shipyards.

U.S. Shipping and Shipbuilding: Trends and Policy Choices (1984) was prepared by the U.S. Congressional Budget Office. The report contains historical background, a good description of the link between shipyards and national security, and strategies for maintaining a national shipyard base.

The Shipyard Mobilization Base (SYMBA) Study (1984), conducted by the U.S. Navy and U.S. Maritime Administration, assesses the capability of the shipyard mobilization base to meet a specified wartime scenario. The report provides a realistic notional war scenario upon which to base analysis, and also defines the government criteria used to determine which shipyards are to be included in the shipyard mobilization base. This study concluded that the 1982 shipyard mobilization base of 119 yards was sufficient to meet the demands of a three year global conflict. However, the report

indicates that some production bottlenecks would occur, and that peacetime Navy work alone would not be sufficient to maintain a civilian shipbuilding and ship repair industry sufficient for national defense in the long-term.

The National Defense Shipyard (NADES) Study (1985) is a subsequent attempt by the U.S. Navy and U.S. Maritime Administration to assess the capabilities of a shipyard mobilization base smaller than the SYMBA base. The model for this study projected the shrinkage of the shipyard mobilization base to 66 shipyards and addressed only the first eight months of the war scenario. As with SYMBA, NADES stated that even this shipyard base was capable of meeting the early demand for shipyard work in a mobilization.

Analysis of the International Competitiveness of the U.S. Commercial Shipbuilding and Repair Industries (1985) was published by the U.S. International Trade Commission. This report compares current United States Government supports to shipyards with the actions of several foreign governments. It also analyzes the causes of recent U.S. non-competitiveness in the commercial shipbuilding arena.

The Commission on Merchant Marine and Defense, established in 1986, was a presidentially mandated commission comprised of distinguished Americans and U.S. Maritime Administration staff workers. The charter of

the commission was to examine the ability of the U.S. Maritime Industries to support national security interests in wartime. During 1987-88 the commission authored a series of three reports on the U.S. shipyard industry as an integral part of American seapower. The first report deals with the 1987 status of U.S. shipyards, and provides an explanation of the methodology used by the Department of Defense in determining sealift requirements. The second report, published in early 1988, provides the commission's recommendations as to government action to reverse the decline of the shipbuilding/ship repair industry. In late 1988, the third report of the commission provided a statistical update on the industry, as well as a more detailed assessment of the physical facilities and manpower available to meet the proposed scenario. These reports are an excellent source of statistical information on the industry, and contain an analysis of the critical equipment supplier base.

The Report on Survey of U.S. Shipbuilding and Repair Facilities (1987) is an annual publication of the U.S. Maritime Administration. It is a compilation of statistics relevant to the shipbuilding and ship repair facilities considered to be in the U.S. shipyard mobilization base. The publication contains narrative descriptions and diagrams of the yards capable of constructing ships, and provides a comprehensive matrix

of over 100 shipyards, listing the workforce population and number of berths and docks for each. The shipbuilding and ship repair industry is extremely fluid, with changes in ownership and merger of shipyards commonplace. This publication is invaluable in providing a succinct description of the status of the industry's physical plant.

The U.S. Maritime Administration's Ships in the National Defense Reserve Fleet - By Design (1988) is an extremely valuable reference. It provides the location of all ships in the NDRF, plus a general description of their function and maintenance status. Additionally, the report lists ships of the Ready Reserve Force (RRF). These ships would be the first ships reactivated in a future conflict. Rapidly returning these ships to service would be crucial to the early resupply of overseas theaters. The report lists the RRF ships by present location, and details which shipyards would be tasked with reactivations and how many days the reactivations should require.

A draft copy of the 1989 Production Base Analysis (PBA), prepared by the Naval Sea Systems Command (NAVSEASYSCOM) has been obtained. This report has proven invaluable in a number of uses. The analysis addresses the ability of the U.S. industrial base to meet the demands for Navy and merchant ship repair and construction in a four-year conflict. The Navy's

Acquisition and Logistics Information Analysis System (ALIAS) computer model was used in the project. This model inputs shipyard resources, manipulates shipyard scheduling against notional job time requirements, and produces an analysis of the number of taskings that could be completed in a given timeframe. The PBA also contains an excellent narrative description of the shipyard equipment supplier industry.

Periodicals

In the field of periodicals, two publications were of recurring value. Proceedings, published by the United States Naval Institute, and Seapower, published by the Navy League of the United States, have published numerous articles related to the shipbuilding and repair industry during the last several years. The articles, by authors from the military, academic, and industrial sectors, provided diverse views on the current state of the industry.

Studies Conducted by Individuals and Private Industry

Many studies on the subject of shipyard mobilization have been undertaken by students at service colleges. Industrial Mobilization: Issues for the 1990's (1986), written by LCDR Carol Jori at the U.S. Naval War College, examines the shipyard mobilization issue as part of a broader look at the mobilization potential of the U.S. heavy and light industry.

The United States Shipyard Mobilization Base: Is It Ready For War? (1985) was prepared by CAPT Paul Tobin, et.al. at the Industrial College of the Armed Forces. The paper details the history of government studies on the shipyard mobilization issue and contains the authors' analysis of each study with regards to completeness and validity.

Two studies specifically address the question of the availability of skilled labor to man shipyards during mobilization. The first, A Shipyard Critical Skilled Labor Model For Determining Shortages During Mobilization (1988), written by CDR Alan Katz at the U.S. Naval War College, is quantitative in nature. Using computer derived man-hour requirements for ship construction and repair, CDR Katz identified potential shortfalls in specific categories of skilled workers in various geographic regions. The second study, The United States Shipyard Mobilization Base: Manpower Requirements (1985), was written by CAPT Robert Dillman and CDR Samuel Major at the Industrial College of the Armed Forces. The report summarized the findings of the authors concerning the availability of skilled labor in a shipyard mobilization. After interviews with the management of nine major shipyards, the authors concluded that no serious manpower constraints would be encountered in a major mobilization. However, because of the continual

downward trend of industry employment, the authors recommended periodic re-examination of the issue.

Several useful reports have also been prepared by private industry and defense research organizations. In early 1988, the Shipbuilders Council of America released two annual reports, the Ship Repair Report - 1987 in Review, and the Ship Construction Report - 1987 in Review. Read together, these publications provide an excellent snapshot of industry activity in 1987. They are particularly valuable in identifying trends that have the potential to have a long-term effect on national security.

Lifeline in Danger: An Assessment of the United States Defense Industrial Base (1988), prepared by the Air Force Association and USNI Press, is a comprehensive examination of the decline in the U.S. defense industrial base. The report deals with the manufacture of sophisticated electronic components used in weapons systems, the dependence of the U.S. on imported raw materials, and the decline in U.S. heavy industry, with emphasis on shipbuilding and ship repair.

Transcripts of Congressional Testimony and Seminars

Transcripts of testimony before the U.S. House of Representatives Subcommittee on Merchant Marine in 1987 and 1988 have been reviewed. The testimony relates to the state of the merchant marine and two bills designed to aid the shipbuilding industry. The transcripts

provide a good sense of congressional attitudes toward the shipbuilding industry.

In 1987, the United States Naval Institute sponsored a seminar on the decline of the U.S. Merchant Marine. The panel of speakers included U.S. Navy and maritime industry leaders. Their testimony provides a fine insight into options for preserving U.S. maritime industries.

Interviews and Correspondence

In support of this thesis, contact was made with cognizant individuals at several government agencies. Among the individuals contacted was Ms. Nancy Harris of the United States Maritime Administration. She has participated in numerous studies of the shipyard mobilization base. She was consulted concerning the Maritime Administration's requirement for ship reactivation, construction, and repair in a future conflict.

Mr. John Bissell of the Naval Sea Systems Command, Industrial Mobilization Division, was interviewed concerning his organization's Production Base Analysis.

Mr. William Ennis of the Philadelphia Naval Shipyard also consented to be interviewed. Mr. Ennis was closely involved in the update of the Production Base Analysis, specifically with regard to the shipyard equipment supplier base.

After telephone conversations, questionnaires were mailed to the personnel divisions of seven major civilian shipyards on the Atlantic, Pacific, and Gulf Coasts. In the questionnaire, shipyard management was asked, based on the current labor situation, to assess their capability to rapidly add workers to their production force. The questionnaires were general in nature, and only four responses were received. While this small sampling cannot be considered scientific, it provided insights into shortages of skilled labor in today's shipyard industry.

Methodology

To answer the subordinate question, "What lessons can be learned from the history of the industry?", an examination of the evolution of the industry is conducted in Chapter 2. The specific focus is the industry's performance during this nation's twentieth century conflicts. This research points to several critical trends important both to the question of industrial mobilization and the need for government aid to the shipbuilding/ship repair industry in the future.

Since the United States shipbuilding/ship repair industry does not operate in a vacuum, a brief examination of the world shipbuilding/ship repair industry is also presented.

The central question of the thesis can be answered by the comparison of two sets of data. The first data set consists of the requirements for repair, reactivation, and construction of ships. These requirements are highly sensitive to the scenario selected for the protracted conflict. To standardize my efforts with that of earlier work, I have chosen the war scenario first detailed in the 1983 Shipyard Mobilization Base Analysis. This scenario envisions a three-front global war of sufficient length to allow large-scale industrial mobilization. The requirements for ship reactivation and construction can be forecast in a fairly precise manner. The requirements for repair of battle-damaged ships are the result of Navy wargaming and are subject to an inherent margin of error. The Naval Sea Systems Command (NAVSEASYSCOM) Production Base Analysis (PBA) reflects the latest government thinking on the demands of future conflict. Although the PBA is a classified document, much of this information is critical to producing a relevant thesis. Through interviews with NAVSEASYSCOM personnel I have gleaned as much unclassified information as possible from the report.

The second set of data to be collected encompasses the resources that the U.S. shipbuilding industry must assemble to meet the production challenge. For purposes of analysis, resources are categorized as: physical plant, trained work force, and equipment

suppliers. In few other industries is the successful blending of a complex physical plant, skilled manpower, and a huge number of component equipments into a finished product as critical as in shipbuilding. Possessing two of the three of these elements is not enough. The inadequacy of any part of this triad dooms efforts to failure. As such, the physical plant, work force, and equipment suppliers were analyzed separately, but as integral parts of a whole.

To analyze the capabilities of the physical plant, a snapshot of the industry's present assets was examined. These assets include: pier space for berthing ships, drydocks for reactivation and repair of ships, graving docks and ways used in the construction of ships, and other facilities, such as marine railways, critical to the construction and repair of ships.

The examination of the adequacy of the trained work force relied on both statistical data, government and private studies, and interviews with government and industry sources. Because of the geographic distance between this research and the shipyards being studied, statistics on the current state of the industry work force were used to identify potential shortfalls. However, employment figures for the industry as a whole did not identify specific problem areas related to geography or a particular skill. The only way to obtain this information was to talk directly to the employment

divisions of shipyards. These organizations are responsible for filling large numbers of vacancies created periodically in this highly cyclical industry. Through questionnaires and telephone interviews, some information on skill shortages was gained. I also relied upon research previously conducted by Commander Katz in the preparation of his shipyard skilled labor model.

The assessment of skilled manpower availability was quite subjective, and could vary significantly from region to region. Also, much of the information regarding hiring was considered proprietary by shipyard management and was difficult to extract. For these reasons, I relied substantially upon the work of others, to supplement my own, to present the broadest base of facts and expert opinions possible. However, the availability of skilled labor was by far the most difficult resource to quantify in a thesis of this length and depth.

Finally, the status of the equipment supplier base was examined by the use of government and private studies. Due to the vast size and diversity of this industry, precise quantifications of all potential shortfalls was not possible. Instead, emphasis was placed on suppliers of major equipment critical to the reactivation, construction, and repair of ships.

Fortunately, the Production Base Analysis study, completed by NAVSEASYSCOM and the Philadelphia Naval

Shipyard in early 1989, had examined the availability of 15,000 items deemed critical to the assembly of ships. By factoring in lead times and production capacities the most serious shortfalls were forecast.

An analysis of the physical plant assets, skilled work force, and equipment suppliers will support an answer to the basic research question.

ENDNOTES

(1) "Era of U.S. Built Ships Draws to a Close," Kansas City Star, November 11, 1987.

(2) Commission on Merchant Marine and Defense, First Report of the Commission on Merchant Marine and Defense: Findings of Fact and Conclusions, 1987, p. 8.

(3) Ibid., p. A178.

(4) Ibid.

(5) United States Congressional Budget Office (CBO), U.S. Shipping and Shipbuilding: Trends and Policy Choices, 1984, p. 47.

CHAPTER 2

BACKGROUND

From the time of the arrival by sea of the first colonists in the new world, the United States has been a maritime nation. Its development, economic, political, and military has been firmly linked to the sea. This seafaring heritage is built upon the exploits of American Navy and merchant sailors in all corners of the globe. But just as important as the achievements of the men who "Go down to the sea in ships" have been the labors of the American men and women who have built and repaired the ships on which this nation's economic vigor and military strength have rested.

The history of the United States shipbuilding and ship repair industry has been marked by several trends: cyclic expansion and contraction based on economic and political factors, varying success in the pioneering of new technology, and the ability to produce in awesome quantity in times of national emergency. A brief examination of the history of the United States shipbuilding and ship repair industry, including these factors, will be valuable in answering the basic research question.

Colonial Shipyards

The 1631 launching of the seagoing vessel "Blessing of the Bay" in Massachusetts ushered in the era

of colonial shipbuilding.(1) For the next two centuries, the shipyard industry of the colonies, and subsequently the United States, expanded and prospered impressively, turning out merchant vessels of all types, and beginning in 1690, warships for the Royal Navy.(2) By the time of the Revolution, each colony had a shipbuilding industry with New England being the most prosperous, followed by the Chesapeake Bay area.(3) The reasons for success were multifold: the American shipyards were in close proximity to the most crucial raw material in shipbuilding, wood. The construction of a large warship would require about 2,000 century old oak trees along with numerous other woods.(4) This supported the British mercantilist trade philosophy of allowing the colonies to supply raw materials for the commerce of the mother country.(5) Also important to the British was the burgeoning trade with new world colonies and exploitation of their resources, including whales and fish. These activities in the western hemisphere demanded a strong shipbuilding and repair industry in the colonies.(6) However, the most important factor in the rapid rise of American shipbuilding was the cost of production. American shipyards were able to build good quality vessels at prices considerably lower than their British counterparts. North American yards could build their best ships for 3 to 4 pounds sterling a ton compared to 5 to 7 pounds sterling a ton in Great Britain.(7)

The most important craftsman in the production of these colonial ships was the shipwright. He combined the skills of a carpenter, caulker, joiner, and painter. He not only had to build a ship's hull but turned out masts, spars, and even blocks for the running rigging.(8) The shipwright was a true "artisan", and his skills were highly in demand.(9) The task of installing the majestic sails and rigging was assigned to master riggers.(10) Copper was used extensively to clad the hulls of vessels, and some iron was used in fittings. As a result, the metalsmith trade made important contributions to the final assembly of vessels. The precursor of today's shipyard equipment suppliers, the ship chandler, also developed into an important industry. Chandlers supplied a wide assortment of supplies, including cables, lead lines, deep-sea lines, twine, oakum, compasses, glasses, sailcloth, and anchors.(11) Along with sailmakers and ropemakers, the chandler ensured newly constructed ships were fully outfitted and ready to sail.

The actual construction of ships was manpower intensive and time-consuming. As described by Ernest Eller:

> Eighteenth-century shipyards were without much machinery and most work was done with hand tools. Even sawmills powered by water were rare. Sawn timber and plank was produced by "saw gangs" of three or four men. Logs were rolled over a pit and two men worked a large ripsaw, one from above, the other below. The rest of the team placed the

> logs into position and then moved the finished work on. Four planks to the log was the usual product. There was much waste. The broadax and the adz - the latter cutting across the grain and the former with it - were used for shaping most heavy structural timbers. Other hand tools - augers, axes, hammers, chisels, and gouges - were used for detail work.
>
> The ship itself was built in the open air and it was the custom in English yards to allow the frame to stand exposed to the weather for as long as a year before her ribs were planked. Although exposure was supposed to season the frame, the wetting and warping resulting from rain and sun triggered dry rot before the ship was launched. Some ships were said to be "as green as grass" from mildew and fungus even before their sides were covered over.(12)

In spite of these conditions American shipyards produced an impressive variety of ships, totalling almost 23,000 vessels in the year 1771 alone.(13)

The vessels American shipyards were building during the pre-revolutionary period had another valuable attribute: speed. This was due in large part to British restrictions on trade between the thirteen colonies and other non-British possessions in the western hemisphere. These restrictions, prohibiting the trade of goods between the colonies encouraged large-scale smuggling.(14) As a result, American ship design placed a premium on the speed required to outrun British Men of War.

America's Early Years and "The Golden Age"

With the coming of the American Revolution, these fast vessels proved invaluable as privateers, wreaking havoc on British merchant and naval shipping alike.(15) The early attempts of the Continental Congress to construct a Navy were considerably less successful. The program for construction of 13 warships, authorized in December 1775, was plagued from its inception by political and material problems. The Marine Committee, responsible for assigning contracts, chose builders in several colonies based largely on political considerations.(16) This, coupled with a lack of blueprints resulted in delays in the commencement of construction.(17) During construction, progress was hampered by shortages of both equipment and skilled workers. Due to British destruction of manufacturers and seizure of equipment itself, shortages of everything from guns and anchors to cordage and sails caused delays in construction.(18) No authority existed to allocate these scarce supplies among builders.(19) By the time of the revolution, the supply of huge trees suitable for main masts had also been depleted, as only one tree in 10,000 was suitable for the main mast of a ship of the line.(20) The competition for shipwrights was also fierce. Most shipwrights could make better wages building privateer ships than working for colonial governments.(21) By

1777, 11 of the 13 warships had been completed; the other ships were never built due to a shortage of manpower.(22)

American shipyards played an important though not pivotal role in the Revolution. The fast ships they had built for generations had proved invaluable to privateers, making possible their disruptive actions against the British. Shipyards had also given birth to the fledgling continental Navy. However, several difficulties were encountered in constructing ships for the national defense. Shortages of critical skilled labor and construction materials had delayed, and in some cases ended construction of ships.

The decade after the end of the revolution saw a depressed market for American shipyards, owing to the loss of the British market. In 1789, however, the powers of the federal government over trade were greatly broadened by the enactment of the Constitution. And among the earliest acts of the First Congress were laws to protect American shipbuilders. These laws, the Navigation Acts, included provisions requiring U.S. flag ships be built in U.S. shipyards, and new fees and taxes that effectively closed American coastal trade to foreign ships.(23)

Boosted by these early government protectionist efforts, U.S. shipyards prospered. By 1795, 92 percent of American imports and 86 percent of exports were carried in U.S. flag ships.(24) The early part of the

19th century saw a change in ship design priority. The 1815 Treaty of Paris made the seas a safer place upon which to conduct commerce.(25) As such, the emphasis in ship construction shifted from speed to size. American shipyards tooled up to build larger ships, in the 1,000 to 2,000 ton range; in doing so the size and sophistication of shipyards increased by necessity.(26) However, even as American shipyards were increasing the size of their products, events on the world trade scene once again made the fast ship a valuable asset. These events were the development of three key long distance sea routes that were best plied by ships that were large and fast: the North Atlantic passenger routes, carrying immigrants; the "China Trade" to the newly opened orient; and the California trade, fueled by the gold rush.(27) American shipyards again responded admirably, producing the large, fast, and beautiful clipper ships of the period 1830-1855. The ability of American shipyards to produce a product perfectly suited to the need, for a competitive price, made the generation prior to the Civil War the "Golden Age" of American shipbuilding.(28) With the exception of wartime production surges, American shipyards have never again equalled the shipbuilding prowess of this era.

Long-Term Decline

The dark clouds building on the horizon for American shipbuilders were both economic and political. The great success that American shipyards had enjoyed in building fast, wooden sailing ships had blinded most American builders to coming changes in technology, both in the construction and propulsion of ships.

The ascendence of steam powered iron ships was certainly not an overnight development. As early as 1807 Robert Fulton, an American, had demonstrated the viability of steam propulsion (29), and the British had begun construction of iron-hulled vessels in the 1830s.(30) That American shipbuilders largely turned their backs on these revolutionary developments was due to two main factors: American complacency, brought on by the huge commercial success of wooden sailing ships; and the primative state of the American iron industry as compared to that of Great Britain. Most American foundries were unable to produce heavy iron forgings required for steam power plants; American industry could not produce machine tools and plate benders for constructing seagoing steamers.(31) This material had to be imported from England, and after duties levied by the U.S. government, the construction of iron, steam-powered ships was simply not economically sound.(32) By the late 1850s the British merchant Marine was thirty percent iron; the perfection of the screw propeller and the

lightweight steam engine allowed British ships to cross the lucrative North Atlantic trade route in 15 to 17 days less than sailing ships.(33) The results of this technology leap on American commerce and shipbuilding were predictable as described by Samuel E. Morrison:

> In 1857, the British Empire had an ocean-going steam tonnage of almost half a million tons as compared with ninety thousand under the American flag. England had won back her maritime supremacy in fair competition, by the skill of her engineers and sturdy courage of her shipbuilders.(34)

The Civil War provided an economic boost to northern shipyards during the period 1861-1865, but ironically accelerated the decline of the industries international competitiveness. Union shipyards concentrated their construction efforts on monitor-type vessels. These small ships, wooden below the waterline with ironclad weather decks and superstructure, bore no relationship, in appearance or construction process to the fast ocean-going steamers being produced by the British. In fact, only one ironclad man-of-war was built for the Union Navy during the Civil War. As a result, the skills, such as metal platebending, involved with the construction of large, metal-hulled vessels, went largely unpracticed for five years.(35)

The end of the Civil War brought no improvement in the lot of U.S. shipbuilders. Non-competitive U.S. metal industries continued to plague efforts to modernize. By 1866, the editor of the New York Times proclaimed that "Shipbuilding in this country is all but completely destroyed."(36) It was during this dark period that the first major debates occurred concerning an issue that is still with us today. Since the late 1700s, the Navigation Acts had mandated that U.S. registered vessels be built in U.S. shipyards. American commercial shippers, desperate for technologically advanced vessels to compete with the British, proposed repeal of the Navigation Acts to allow the purchase of British ships for the American merchant fleet. While these "Free Ship" proposals in the late 19th century were not implemented, they serve to point out a common thread in maritime industry that is still true today: interests and tactics for the shipbuilder and ship operator are divergent. In the United States, what is beneficial for one is often economically destructive for the other.

Adding to the woes of the shipbuilders was an almost complete cessation in Navy shipbuilding after the Civil War. Two small gunboats were the only ships laid down in the generation following the Civil War.(37) Once again, U.S. shipyards missed out on a technological revolution, this one in warship and weapon design - improved steel hulls, compartmentation and guns.(38)

This period of dormancy existed until the mid 1880s, when the first Naval Advisory Board (NAB) was formed. Thanks to the influence and congressional lobbying of the NAB, a program to construct thirty modern naval vessels was implemented between 1885-1895. This first large peacetime building program moved the Navy into an important position in the shipbuilding and repair industry.(39) Although most ships were constructed in the government naval shipyards, any increase in the potential repair/construction market was a welcome prospect to the hard-pressed civilian shipyards.

The quarter century before the outbreak of World War I saw little real change in the fortunes of the shipbuilding and repair industry. The technological advance in world shipbuilding continued, with improvements in hull design and propulsion triggering the development of a variety of new, specialized ships, including passenger liners, refrigerated ships, oil tankers, and the famous "tramp steamer" designed to carry bulk cargo.(40) During this time, American shipyards were also undergoing a metamorphosis, from small family-owned businesses to large corporate concerns. This development was a natural outgrowth of the move to increasingly large, complex vessels requiring more sophisticated shipyards for construction and repair. But this evolution could not help American shipyards redress the basic problem that had plagued them since the Civil

War. The inability to build quality ships for a price competitive with the shipbuilding masters of the age: Henry Scheider of France, the Krupps of Essen, and Nickers of England.(41) The roots of the problem, expensive domestic iron and lack of technical expertise relegated American builders to constructing small ships for the government-protected coastal trade.(42) This minor level of activity was unable to support even the small national security demands of the Spanish-American War of 1898. During this conflict, the U.S. government resorted to purchasing ships from foreign builders to support its conflict with Spain.(43) In 1912, duties had been removed for most imported shipbuilding materials, but this victory for the shipbuilders was largely mitigated by other legislation allowing the registry of foreign-built ships under the American flag.(44) By 1915, only ten percent of American foreign commerce was shipped in U.S. flag, U.S. built vessels.(45) It would take the impending cataclysm in Europe to change the situation.

World War I

When Americans examine the history of World War I, the tendency is to concentrate on 1917-1918, the years in which the U.S. was directly engaged in the fighting. But the events of 1914 had a jarring effect on the American economy, and prodded the U.S. government into setting in

motion the first of two great shipyard mobilizations of this century. As noted above, by war's start only ten percent of American commerce was carried in U.S. flag ships. The United States relied predominantly on British, German, French, and Italian ships to transport critical exports, particularly agricultural products, to overseas markets.(46) With the outbreak of war, most of these ships were withdrawn by European nations to support their war efforts. The effect was quick and disastrous. With insufficient ships to move America's 1914 bumper harvest, agricultural products piled up at docks, prices plummeted and crops rotted in the field or were burned for want of transportation.(47)

This jolt to the American economy revealed the weak state of America's merchant Marine, as well as the very limited ability of American shipyards to build enough ships to quickly redress the problem. At the start of the war, there were 61 private U.S. shipyards (48), employing 45,000 workers, with 235 building ways capable of constructing oceangoing merchant vessels.(49) Those concerned with expanding the American merchant fleet contended these yards, with minimal experience or skills in building oceangoing vessels, would not be able to meet the increasing demands of American commerce and defense. In 1914 the Wilson Administration proposed the establishment of a government body responsible for contracting for and operating U.S. merchant ships in time

of national emergency.(50) This proposal was strongly opposed by commercial shipping interests during 1914-15, due in part to their distaste for involvement of the federal government in business and also due to the fact that the scarcity of shipping had increased geometrically the fees existing shippers could charge.(51)

By September 1916, however, the continuing drift of the United States from a position of neutrality to active belligerency moved industry and Congress to accept President Wilson's Shipping Act of 1916. This act established a five member Shipping Board (USSB) an independent agency with broad powers to purchase, build, and operate government-owned ships (52); the act was of a temporary, emergency nature and prohibited the shipping board from carrying on business more than five years after war's end.(53)

From the latter part of 1916 to the American Declaration of War in April 1917, the progress of organizing the shipbuilding program was slow, plagued by bureaucratic squabbles within the USSB, labor unrest, and the fact that most shipbuilding ways were already occupied with vessels of various descriptions.(54) In Summer 1917, President Wilson moved to restructure the USSB leadership and placed its operations directly under presidential authority.(55) Under this close scrutiny, work accelerated on both ships and shipyards. The USSB took control of all private shipyards and vessels under

construction.(56) The initial plan for ship construction called for the building of over 150 government shipyards and 15 million tons of vessels.(57)

The success of the shipyard/shipbuilding program was mixed, for numerous reasons. The program attempted to build up during a period of chaotic mobilization of the U.S. economy as a whole. In spite of the 1917 formation of the War Industries Board to referee disputes over limited resources and set priorities for production, the overall mobilization of U.S. industry was a haphazard affair until the final months of the war, with equipment shortages and production bottlenecks common.(58) Nevertheless, the construction of government-built shipyards was impressive in number: by war's end, 158 shipyards had been built by the government, including the mammoth Hog Island Yard, south of Philadelphia, which had 50 building ways alone.(59) Overall, by November 1918, the U.S. shipyard base had blossomed to 341 shipyards, employing 380,000 workers on 1,284 building ways.(60) However, building these yards took time, and the months required to set up for mass-production of ships fated most vessels to be completed after the cessation of hostilities. It was the summer of 1918 before large numbers of ships began coming off the ways, with the average time to build a cargo ship being 10 months.(61) Hog Island did not launch its first vessel until one month after the Armistice was signed. In fact, not one

vessel ordered after the April 1917 declaration of war was ready to participate in action prior to war's end.(62) It is generally felt that the USSB's efforts in gathering up large amounts of existing shipping for the war effort were more critical to allied victory than the new ships they constructed. However, the fact that the war ended before the shipyard mobilization could fully weigh in should not by any means trivialize the industrial feat performed. The USSB was responsible for the eventual construction of 2,312 ships at 13.6 million tons, raising the U.S. portion of world shipping capacity from 7 percent in 1914 to 22 percent in 1920.(63)

The World War I experience in shipyard mobilization taught several important lessons. Given the resources and priority, the capacity and workforce of shipyards could be expanded impressively. But just as important, it was found that any large expansion that started with a small, underutilized industry would take a great deal of time to come to fruition, with the possibility the war would be over before production goals were reached. This implied greater government involvement in the forecasting of national security requirements and the need to maintain a "warm" peacetime industrial base capable of rapid expansion.

The Years Between the Wars

Although the shipyard build-up of World War I came too late to have a major impact on the conflict, one positive result was the restoration of American shipping to world primacy, if only temporarily. By 1920, the United States possessed the world's largest merchant fleet, comprising 22 percent of total world tonnage.(64) The vast majority of these ships were government built and owned, however, and with the end of hostilities, the Shipping Board's limited mandate was running out. This atmosphere saw the congressional passage of the Merchant Marine Act of 1920, commonly referred to as the "Jones Act". In addition to laying down groundrules by which the government's huge merchant fleet could be sold off, the Jones Act contained three provisions for government support of the shipbuilding industry. They were:

1. The establishment of federal mortgage guarantees for construction of vessels in U.S. shipyards.

2. The establishment of a 25 million dollar construction loan fund.

3. The reinstatement of the requirement that all U.S. domestic trade be carried in U.S. built, owned and crewed ships. This requirement for "cabotage" had been rescinded during World War I.) (65)

The Jones Act was a strong statement by the government of its intent to preserve the vitality of U.S. shipyards. Economic conditions during the 1920s and

1930s, however, forced the pendulum of U.S. shipbuilding down again. The early 1920s saw a glut in world shipping capacity (66) caused by the massive shipbuilding programs of World War I. With prices for "used" ships at rock bottom the demand for new ships plummeted. Table 2-1 illustrates this decline in U.S. merchant vessel construction.

Table 2-1

Merchant Vessels Constructed in U.S. Shipyards

(1918-1930) (67)

Year	Vessels Built
1918	386
1920	450
1925	11
1930	16

The few vessels built in the late 1920s were almost exclusively for the domestic routes protected by the Jones Act. This situation stemmed from the fact that shipbuilding costs in the U.S. still exceeded that of Great Britain by 60 to 70 dollars a ton.(68)

The end of World War I had seen the closure of the government-owned shipyards, and as the shipbuilding depression of the 1920s continued, dozens of private yards began to disappear.(69) Only the largest and strongest yards survived, including Newport News

Shipbuilding, Bethlehem Steel, Electric Boat, and Bath Iron Works.(70) These yards continued to operate with an emphasis on repair jobs, Navy orders, and scattered construction work.(71) The years 1929 to 1933 saw some increase in business due to the Merchant Marine Act of 1928, which encouraged the construction in U.S. shipyards of new vessels to carry overseas U.S. mail; and increased the construction loan fund to 125 million dollars.(72) Approximately 40 vessels, mostly cargo and passenger types, were built during this period.(73) In addition, the government sought to discourage the repair of U.S. flag vessels in foreign shipyards. The Tariff Act of 1930 demanded a 50 percent velorum tax be paid by the U.S. ship operator, for any non-emergency repairs performed in a foreign shipyard.(74) But as the entire American economy moved into depression, the shipbuilding industry continued its downward spiral, until by 1935, only two oceangoing merchant vessels were built in U.S. shipyards. By 1937, this lack of business had winnowed the shipbuilding industry down to 10 shipyards with 46 building ways, (75) employing 60,000 workers, capable of building oceangoing ships.(76) From these depths, a combination of government intervention and world events were to drive the U.S. shipbuilding and repair to its greatest series of accomplishments.

The inauguration of President Roosevelt in 1933 saw the rise of overt government involvement in

regulating business and industry. The terms "First 100 days" and "alphabet soup" became household words, describing the flood of legislation passed and plethora of government agencies established to regulate commerce and industry. In this atmosphere, the Merchant Marine Act of 1936 was passed. This act, sometimes referred to as the "Magna Charta" of the American maritime industry (77) marked a shift from government encouragement of U.S. shipbuilding by favorable trade policies to one of outright subsidization of the shipbuilding process. It still serves as the basis for many of today's maritime policies. Salient sections of the act included:

1. The establishment of the Construction Differential Subsidy (CDS). This subsidy provided for government payment to U.S. shipyards building ships for American foreign trade shippers, the monetary difference between U.S. construction cost and foreign construction cost, up to 33 1/3 percent.(78) For example, a U.S. shipbuilder constructing a qualifying ship for 12 million dollars would, if the foreign price was determined to be 10 million dollars, be paid 10 million dollars by the shipper and 2 million dollars by the federal government.

2. A provision allowing ship owners to deposit funds from the sale of vessels in a tax-deferred account to be used to pay for construction in U.S. shipyards.

3. In 1938, an amendment (Title XI) establishing "Federal Ship Mortgage Insurance". This allows the federal government to insure private loans for ship construction and repair in U.S. yards.(79)

4. Establishment of the U.S. Maritime Commission, a five-member independent regulatory body to administer the various aspects of the program. The Commission was also given the power to contract for the building of ships at government expense for charter to shippers if the above provisions did not stimulate private shipbuilding.(80)

The Maritime Commission wasted no time in flexing its mandated muscle. In 1936, the Commission moved to counter what it considered the block obsolescence of the U.S. merchant fleet, which had been largely constructed during World War I. The Commission determined that the construction of 50 merchant ships annually for 10 years was required.(81) Through CDS and procure and charter, the Maritime Administration initiated construction on 50 ships for 15 shipping companies.(82) The Commission went so far as to produce a family of standardized plans and drawings for three durable, versatile types of cargo ships to be constructed.(83) Future events would vastly change this shipbuilding program, but in the late 1930s the program's positive effect was already being felt in U.S. shipyards. In 1935, 63,000 gross tons of merchant vessels were built in the U.S. By 1939, this number had risen to 340,000.(84)

World War II

The year 1939 also marked the beginning of the conflict that was to provide the U.S. shipbuilding

industry its greatest challenge. The German invasion of Poland in September and the subsequent commencement of U-boat warfare against the British Merchant Marine placed the inability of allied shipyards to rapidly build ships in sharp focus. In October 1940, the British government requested American assistance in building 60 dry cargo ships of 440 feet in length, 11 knots speed, and a cargo capacity of 10,000 deadweight tons.(85) The U.S. government, mindful of the accelerating drift toward war, made the decision in late 1940 to order 200 vessels of the British design for the U.S. merchant marine.(86) These vessels were to become the first of the "Liberty Ships" so essential to allied victory in the Second World War.

For purposes of analyzing the historical lessons of the shipbuilding explosion that began with the construction of the above vessels, it is useful to examine each of the three critical components of shipbuilding: facilities, manpower, and equipment suppliers separately. First, the facilities.

By 1941, the impetus of the Maritime Commission 1936 building program had increased the number of private shipyard facilities capable of building oceangoing ships to 19.(87) However, the large majority of shipbuilding assets resided in the five largest yards: Newport News Shipbuilding and Drydock Company, Federal Shipbuilding, New York Shipbuilding, Sun Shipbuilding, and Bethlehem

Shipbuilding. These yards were nearly full to capacity with U.S. Navy construction as a result of the July 1940 decision to nearly double the tonnage of the U.S. fleet.(88) It was obvious new shipbuilding yards and ways were required to meet the demand for 260 ships. January, 1941 saw the Maritime Commission receive approval to build nine new shipyards with 65 shipbuilding ways.(89) These new shipyards were financed by the federal government and operated largely by established shipyards. In fact, many of these "emergency" shipyards were simply facilities added on to existing businesses. Seven of the shipyards were to produce the 200 U.S. ships, with two building British vessels.(90) The shipyards were designed specifically with the idea of ship mass-production in mind, as described by Merchant Marine for Trade and Defense:

> Emergency shipyards were constructed to build the standardized Liberty Ship. Traditional methods of shipbuilding were streamlined. Formerly ships were built plate by plate. Each piece was cut in accordance with a model and then the piece was riveted into place. But Liberty Ships were built in huge sections. In shops close by the launching ways an entire forepeak or deck housing would be welded together and lifted into place by giant cranes. Sometimes two to four cranes, each capable of lifting 50 tons, would be used together. The shipbuilders were able to employ some of the speedy assembly-line methods used so successfully by America's automobile industry.(91)

This radical departure from previous technology was made both possible and essential by the scope of the

task: the rapid production of hundreds of simple, identical vessels. In the course of the war, an additional 12 of these highly specialized and productive emergency yards were added to the shipbuilding base. The construction of these shipyards was a time-consuming evolution in itself. The average time to construct a new shipbuilding way for the Maritime Commission program was six months. The Bethlehem-Fairfield yard near Baltimore with 16 ways was built in 21 months, an incredibly short period of time for such a large facility.(92) In spite of the competing demands of other industries for materials and land, by 1945, 80 shipbuilding yards were producing ships on 300 building ways.(93)

These shipyards were, however, only the stages on which one of the greatest manpower mobilizations in history was played out. The numbers themselves are staggering: private shipyard employment, 80,000 in June 1939, rocketed to 500,000 by the time of Pearl Harbor (94) and eventually peaked at 1,459,000 in November 1943.(95) This 1,800 percent increase in manpower was accompanied by an almost 5,200 percent rise in productivity.(96) The workers drawn to the shipyards were, by most accounts, an interesting mixture. The core of any shipyard was its force of experienced management personnel and foremen. However, the need for a large labor pool attracted many groups unfamiliar with

shipyard work. Katherine Archibald, herself a shipyard worker during World War II, recounts:

> The great expansion in the social areas reached by shipyard demands for manpower consisted in the lowering of the floor and the drawing in of the masses of the unskilled who were customarily ignored by peacetime industry. To the unlettered and untaught, the drifters and the failures, farmers and farm workers scrabbling on the borderline of subsistence, Negroes cramped in opportunity by prejudice, and women who in peacetime constituted only a reserve for casual and poorly paid work - to the entire group of the underprivileged, the exploited, and the unorganized the outburst of shipyard activity gave a chance to participate in the skilled trades and to partake of their rewards. Within these limits the shipyard world was extraordinarily mixed, and brought together in a working relationship many groups which ordinarily were separated by geographical and social barriers.(97)

After a decade of economic depression and possibly a lifetime of discrimination and failure in the workplace, these groups, along with others, provided the shipyards with what they needed desperately: a large supply of workers willing to relocate and perform hard, often exhausting work in all climates. For this, the workers were rewarded with comparatively high wages; on the west coast, for example a shipyard worker was paid up to 50 percent more per hour than an aircraft worker or comparable skill.(98)

Having attracted these workers, the shipyards were next faced with the problem of training. Pre-war

shipyard workers were a relatively skilled workforce. To train a first class mechanic to work on all the internals of a ship might require several years.(99) The shipyards had neither the time nor resources to train the new, inexperienced workers to this level. The shift to prefabricated section construction noted above provided the answer. New workers were taught only a few basic tasks that they would perform countless times on the large volume of ships being produced. In this way, workers could become productive in much less time, just one month in the case of a common welder.(100) This process freed up more experienced workers for more complex jobs.

Althougn working arrangements varied, most shipyards established multiple shift operations, for example, two ten hour shifts and one four hour maintenance catch-up shift per day.(101) Under this system, employees typically worked a 50-60 hour week. These long working hours, coupled with the physically demanding nature of the work, combined to produce both high absenteeism (102) and significant turnover (an average of 10 percent per month).(103)

While these personnel problems were countered mainly by continuing appeals to the patriotism of the workers, the government actively moved to combat industry-wide conflicts. The two most serious problems in the management of World War I shipyards had been

strikes and one shipyard "pirating" the workers of another with higher wages.(104) To deal with these problems, the Shipbuilding Stabilization Board, comprised of management, labor, and government representatives was created. Among the SSB's accomplishments were the establishment of strict rules of labor strikes and employer lockouts and a system designed to minimize the practice of pirating. To achieve the second goal, the SSB divided the country into four geographic zones; standard wage scales were established within these zones, adjusted for respective costs of living.(105) This, coupled with a requirement that a worker desiring to transfer to a new shipyard required a release certificate from his old shipyard (106) served to effectively control pirating.

The assimilation of a massive number of new workers into the shipyard industry was not done without considerable pain and effort. And in 1944 and 1945, competing manpower demands (including the draft) produced some shortages in manpower.(107) However, these problems were decisively overcome by dramatic rise in worker productivity. Examples of the decrease in days required to build ships as the "learning curve' efficiency of workers increased abound: the average time on the ways for Liberty ships decreased from about 150 days in 1941 to 40 days in 1945(108) (One ship was built in seven days)(109); the heavy cruiser USS WICHITA, completed in

1939, required 41 months to build, while the larger USS BOSTON, completed in 1943, was built in 24 months.(110) But perhaps more important, the number of "manhours" required to build merchants and warships plummeted. The average number of manhours to construct a yard's twentieth Liberty ship was just one-third of the first.(111) Manhours required to build Navy destroyers declined from 21 to 34 percent.(112)

Having built shipyards and trained workers in mass production techniques, one vital element remained in the shipbuilding equation: manufacturing and allocating the thousands of component equipments involved in the assembly of ships. While the assembly of a large number of ships quickly was technically feasible, it could not occur if the component parts were not present in the shipyard. Even relatively unsophisticated Liberty ships required 7,500 different types of individual components manufactured by 6,000 separate companies.(113) Prior to Pearl Harbor, a letter rating system (A-1 through A-10) was established by the government to prioritize demand for critical materials. This system, however, being voluntary and subject to "rating inflation" was largely ineffective.(114) After December 1941 more stringent production allocation means were established. The War Production Board (WPB), along with the Navy and Maritime Commission established committees to screen and prioritize shipyard orders for equipment.(115) In spite

of these efforts, shipyards faced significant shortages of the most basic materials during the first year of the conflict.

Leading the list of critical materials was steel. The steel industry, still recovering from the depression at war's start, was simply not able to keep up with vastly increased foreign and domestic demand. The problem was compounded by the fact that the steel plating required by the shipbuilders could not be "just any steel". A 1942 survey of one shipyard revealed that each month, 763 different types of steel plates and 455 different kinds of steel shapes were required for production.(116) These materials had to be available in the proper sequence or immediate delays resulted. Also critical during the early stages of the war was a shortage of "prime movers" - the gears, turbines and diesel engines required to drive the ships. Shortages of these materials caused the failure of shipyards to meet production goals in 1941 and 1942.(117)

The shortfalls were largely overcome by a combination of improved allocation procedures, innovative construction, and the explosion in U.S. manufacturing capability. By 1943, the WPB was involved in the precise scheduling of the manufacture and distribution of "critical" items, including boilers, pumps, and valves. From the construction standpoint, U.S. shipbuilders were at their improvisational best. With the majority of

naval and merchant vessels of simple design. Shipbuilders were able to substitute alternative propulsion and sometimes weapons systems on ships to utilize supplies on hand.(118) This approach also produced savings in scarce, exotic materials, such as brass and copper, which were replaced by galvanized iron on many ships.(119) Finally, the might of American industry weighed in fully in the final years of the war. Again, from Merchant Marine for Trade and Defense:

> One-man workshops and nation-wide corporations doubled and trippled production. Factories that had built stoves learned how to build lifeboats. Companies that had built furniture for homes now built furniture for ships. From every part of the country anchors, drive shafts, ventilators, nuts and bolts, welding rods, engines, and a thousand other materials and parts poured into the shipyards in a scheduled stream to meet the needs of the individual yards.(120)

This melding of management and production skills with new shipyards and over a million workers produced awesome results. The production record of the shipyards from July 1940 to July 1945 speaks for itself, as evidenced by Table 2-2.

Table 2-2

World War II U.S. Shipyard Production (121)

Product	Units Produced
Liberty/Victory Ships	3,037
Standard Tankers	700
Other Transports	1,088
Navy Combatants	1,201
Landing Vessels	64,546

While the raw production statistics of shipyards in World War II are compelling, the lessons to be learned from the period are more useful when looking to the future. Of most significance, research indicates that the entire U.S. industrial mobilization, including shipyards, was not a quick or smooth evolution. Two events, the Merchant Marine Act of 1936, with its resultant government building program, and the two-year delay in American entry into the war, provided the critical time needed to develop an industrial plant with the potential for great expansion. Even given this five year "running start", U.S. shipyards were unable to meet production quotas in the early stages of the war. Shortages of components and raw materials produced bottlenecks overcome only by heroic efforts by government and industry.

From a personnel standpoint, the 1,800 percent increase in shipyard employment from 1939 to 1943 is

extraordinary. However, the training of these workers, even in rudimentary skills, depended upon a cadre of experienced shipyard personnel. Only the maintenance of sufficient "warm" capability in facilities and personnel would allow rapid expansion in time of crisis.

Perhaps the most important lesson of World War II is the need for foresightedness. The government, through the Merchant Marine Act of 1936, recognized the need to modernize U.S. shipping to support the transport of a "significant" portion of American commerce in U.S. built and registered ships. Subsequent expansions of shipbuilding goals prior to Pearl Harbor reflected the government's understanding of the critical nature of seapower in any potential conflict. The need to realistically define future maritime defense needs and plan for achieving them is just as real today.

Shipyards in the Post-War World

The end of World War II saw the United States with a merchant fleet of 4,500 commercially useable ships, more than all other nations combined.(122) In the years immediately following the war, the Merchant Ship Sales Act of 1946 saw the dispersion of this fleet, most being sold to private business (57 percent foreign), and 1,400 being retained in inactive service by the government for use in the National Defense Reserve Fleet (see Chapter 3). In this atmosphere, post-war shipyards were faced with a rapidly shrinking U.S. flag merchant fleet,

greatly scaled back orders from the U.S. Navy, and steadily increasing competition from foreign shipbuilders, including modern, rebuilt Japanese shipyards.(123)

The outbreak of the Korean War did not result in the mobilization of U.S. industry. Government response to increased sealift demands was to reactivate over 500 NDRF ships for service.(124) These reactivations produced significant, but short-term work for American shipyards. Of more importance to the future of U.S. shipbuilders was the Maritime Administration initiative to order 35 new cargo ships, the "Mariner class" vessels.(125) These ships, built between 1952 and 1955 and operated on major U.S. trade routes, were of excellent design and among the fastest cargo vessels in operation at the time.

Unfortunately, however, the two decades after World War II saw an overall decline in American shipbuilding fortunes. Once again, the inability of American shipyards to produce competitively-priced ships in a timely fashion was evident. The phenomenon of "flags of convenience", by which American owners built and registered ships in foreign countries, flourished. Between 1952 and 1977, American shipping companies had 600 merchant vessels built in U.S. shipyards, while contracting for construction of 2,000 ships in foreign yards.(126) During the 1950s, the U.S. government

continued its efforts to encourage building in U.S. shipyards; the Long-Range Shipping Act of 1952 broadened the categories of ships eligible for construction subsidies, and the 1956 Ship Replacement Program provided economic incentives for U.S. shipping lines to build new vessels. These government efforts at stimulations yielded mixed results: some new vessels were built, but their designs were undistinguished and did not provide any marked technological advances.

The decade of the 1960s saw some encouraging technological innovation by U.S.shipbuilders, including the development of container ships, which allowed goods to be shipped more economically and safely. In the 14-year period 1956 through 1969, U.S. shipyards delivered only 268 vessels to American owners.(127) Yet, the ability of the rapidly emerging new shipbuilding powers of the Far East to drastically underbid U.S. builders increasingly relegated American shipyards to rely on U.S. Navy construction and repair work. In 1970, private U.S. shipyards built twice as many Navy ships as commercial vessels.(128) In this same year, however, the government enacted new legislation aimed at reversing this situation.

Passage of the Merchant Marine Act of 1970 offered the promise of revitalization to America's shipyards. The major provisions of this act called for:

1. Construction of three hundred merchant ships, over a ten year period, in U.S. shipyards for American foreign trade. The ships were to be of standardized design, built with mass-production methods. Construction of these ships was to be financed primarily by CDS payments.

2. Extended construction subsidies to bulk carrying and tanker ships not necessarily suitable for use in a national emergency.

3. Broadened the scope of tax-deferred capital construction fund.(129)

The above provisions produced a significant increase in shipyard investment in capital improvements; between 1970 and 1977, $1.3 billion was invested in facility expansion.(130) The number of merchant ships under construction also increased, although the 58 new ships financed under this program from 1970-1975 fell far short of program goals.(131) Still, by 1974, 93 merchant ships of various types were under construction, as compared to 63 naval vessels.(132)

In 1975, world economic events once again produced a shift in shipyard fortunes. The Arab oil embargo following the 1973 Yom Kippur War triggered a world recession; this recession produced an immediate and long-term glut in merchant ships, especially oil tankers.(133) This caused a steady decline in ship orders, until 1981 saw only 50 merchant ships under construction in U.S. yards.(134)

1981 saw the inauguration of President Reagan, who had, along with calls for a strengthened defense establishment, advocated the renewal of the U.S. merchant marine. The Reagan Administration's strong free trade and anti-subsidy leanings, however, seemed to accelerate the end of commercial shipbuilding in the United States. Beginning in 1981, the Reagan Administration did not request funding for the CDS program. This program, with its payments to shipbuilders (which by 1981 had risen to 50 percent of construction cost) had been the only real incentive for shipping companies to contract for the construction of ships in U.S. yards. At the same time, the administration began waiving the previous requirement for U.S. flag, foreign trade ships to be constructed in U.S. yards. From 1981 to 1986, 44 U.S. flag vessels were ordered from foreign shipyards. During the same period, 21 ships were ordered from U.S. shipbuilders, the last in 1984.(135)

This cessation in commercial orders was accompanied by increasing use of foreign shipyards to repair U.S. ships engaged in U.S. domestic trade.(136) The 1930 Tariff Act subjected such non-emergency repairs to a 50 percent ad velorum tax, but the difficulty in enforcing the act and high comparative cost of repairs in U.S. yards (sometimes more than the 50 percent tax) made the practice more attractive.

By the mid 1980s, U.S. shipyard income was derived from three sources:

1. Construction and repair of U.S. Navy ships.

2. Building and repairing ships for the protected (Jones Act) U.S. domestic trade.

3. Repairing U.S. and foreign ships.(137)

These current subjects will be discussed in more detail in Chapter 3.

The Lessons of History

A study of the history of the U.S. shipbuilding and ship repair industry is valuable to this thesis in that it provides several interesting lessons, with respect to the economic status of shipyards and their role in national defense.

The most striking economic trend of the last century has been the basically uncompetitive nature of U.S. shipyards. This has been caused by a number of factors, including the inferior nature of American raw materials, notably iron, in the 1800s and the effect of high tariffs on imported materials. However, the greatest impact by far in this century has been the cost of U.S. shipyard labor. Shipbuilding and ship repair are labor intensive activities, and U.S. shipyard labor is quite expensive relative to many areas of the world.

The next notable trend has been the involvement of the U.S. government, both directly and indirectly, in the nurturing of American shipyards. From the Navigation Acts of the 1700s to the Merchant Marine Act of 1970, the government has attempted with cabotage, subsidies and other vehicles, to develop a healthy industry. These efforts have met with mixed short-term results, but have failed, in the long run, to make U.S. shipyards competitive. In fact, if shipyards were just another industry better left to foreigners, an argument could be made to minimize government efforts in this area. However, twentieth century history has taught us that shipyards can be a precious national defense resource during a prolonged conflict, and as such government must closely involved in tracking the number of shipyards required and strategies for preserving this industrial base.

In examining the two world wars, several lessons are helpful when analyzing U.S. shipyards national defense potential. First, the expansion of the shipyard base was neither a quick or painless process in either conflict. However, the impact of shipyards in World War II was more decisive than in the First World War. This was the difference between starting with a "warm" industrial plant in 1941 as opposed to a cold plant in 1917, as well as the differing durations of the wars. The need for government coordination of the allocation of

scarce wartime resources to minimize production bottlenecks has also been amply demonstrated. Finally, the positive impact of series production of a significant number of identical ships was driven home dramatically by World War II. The astounding improvements in shipyard productivity were caused, in large part, simply by practice and more practice. A shipyard sporadically producing ships of varying designs and complexity may be hard-pressed to quickly increase production.

The main lesson to be drawn, however, is that the U.S. maritime industry, including shipyards, has been critical to U.S. national security in this century, and will be in any future-prolonged global conflict.

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CHAPTER 3

CURRENT STATUS OF THE U.S. AND WORLD SHIPBUILDING AND SHIP REPAIR INDUSTRY

Before examining the current status of the U.S. shipbuilding and ship repair industry, it is worthwhile to review the Department of Defense guidance concerning essential characteristics of this nation's peacetime industrial base. These standards are applicable to U.S. shipyards, as well as all industries with defense potential, and include:

- Provide efficient peacetime production.

- Maintain active peacetime production base capabilities.

- Have the capability to accelerate output through production surge.

- Be prepared to indefinitely sustain combat forces and essential functions of the economy.

- Maintain at least one domestic producer at minimum sustaining rate for critical major weapons systems and secondary items.(1)

While the wartime requirements for U.S. shipyards will be further refined later in this thesis, the above characteristics should be kept in mind as the current state of the industry is examined.

Shipyard Facilities

The label "U.S. shipbuilding and repair industry" implies that the construction and repair of ships in this country is carried out by a group of fairly similar companies, self-sufficient in production materials and pursuing the same general goals and strategies. This is far from the truth. The industry is a complex mix of large and small, private and public yards with greatly varying capabilities. Equally important is the large number of companies supplying the equipment components that go into a modern ship.

Shipyards in the United States can be generally divided into three categories: U.S. naval shipyards, private shipyards capable of performing work related to industrial mobilization (constructing vessels over 400 feet in length and 12 feet in draft or berthing and repairing vessels over 400 feet in length and 12 feet in draft), and shipyards with capacity for the construction and repair of smaller vessels. For purposes of mobilization planning, only the first two categories are considered to be elements of the Shipyard Mobilization Base.(2) A brief description of these two categories follows.

Currently, eight U.S. naval shipyards are active in the United States. Locations include Portsmouth, VA; Philadelphia, PA; Norfolk, VA; Charleston, SC; Long Beach, CA; Mare Island, CA; Bremerton, WA; and Pearl

Harbor, HI.(3) The mission of naval shipyards today, is, as it has been since their founding in the early 1800's, to provide immediately responsive ship repair support to the currently operating Navy combatant fleet, and to be the nucleus from which necessary wartime shipbuilding and repair capability can be mobilized.(4) These shipyards are military installations, and the approximately 33,000 production workers(5) are predominantly civilian government employees. The focus of most naval shipyards is the repair and overhaul of nuclear powered ships and submarines. This is largely due to the complexity of the work involved. According to David Whitehurst: "It takes literally years to build the intricate network of facilities, procedures, skills, qualifications, discipline and dedicated attitudes necessary to do nuclear work successfully."(6)

This is illustrated by the fact that only two of over 100 private shipyards are currently authorized to work on nuclear powered ships, as compared to six of eight naval shipyards authorized.(7) In addition to nuclear work, the naval shipyards specialize in the repair and overhaul of the sophisticated electronics and weaponry common to modern warships. Many skills relating to the repair of older warships, abandoned by private shipyards due to lack of demand, also remain only in the Naval Shipyard Base. For example, the Philadelphia Naval Shipyard operates the Navy's only propeller foundry and

production plant and the Navy's only replenishment winch repair facility.(8) The naval shipyards also possess the ability to rapidly form and dispatch "tiger teams" to any location in the world to provide on-site assistance to ships.(9)

Although initially established with the basic mission of repair and upkeep of the fleet and construction of some naval vessels, the 1934 Vinson-Trammel Act significantly expanded naval shipyards role, specifically stating that naval shipyards would build the first ship of each new warship class. This was done to ensure the preservation of construction skills in the shipyards, and to establish a "benchmark" against which to measure the performance of private shipyards.(10) However, the last naval shipyard construction of a vessel occurred in 1967; the Vinson-Trammel Act has been waived in subsequent years, resulting in the construction of all Navy vessels in private shipyards for the last generation. As a result, naval shipyards retain the physical plant necessary for ship construction, but for twenty years have conducted only repair and overhaul work. In the field of overhaul and repair, however, naval shipyards are awarded with a significant portion of Navy contracts. In fact, after a program of modernization and cost cutting, naval shipyards had become so competitive that in fiscal year 1987 they were awarded contracts totaling almost 70 percent of Navy

repair and overhaul funds.(11) This "good news" for the government was yet another setback for private shipyards, which have come to rely heavily on Navy repair contracts.(12)

Although calls have been heard for the closing of several naval shipyards deemed redundant and inefficient(13), current Navy industrial policy would seem to preclude this. Officially stated requirements are:

- 2 naval shipyards on each coast capable of repairing aircraft carriers

- 1 naval shipyard on each coast capable of overhauling nuclear vessels

- 3 naval shipyards on each coast capable of overhauling nuclear submarines

- 3 naval shipyards on each coast capable of installation, checkout, and repair of current state of the art electronics and weapons systems

- Maintenance of Pearl Harbor Naval Shipyard for all Pacific Fleet ships.(14)

Given this, the current level of eight naval shipyards can be expected to continue in the future. In addition, the number of shipyard workers, which remained virtually unchanged from 1982 to 1987, can be expected to remain relatively constant. This fact has several implications in the mobilization question. First, the naval shipyards will continue to be the backbone of the Navy's repair efforts, in peacetime and war. There are,

however, limitations to the contribution the naval shipyards will make in a future conflict. Naval shipyards have never, nor would they in future conflict, build merchant vessels. Also, the over twenty-year hiatus in naval ship construction means significant delays would be encountered in reestablishing the skills required to build complex naval combatant vessels in naval shipyards, as occurred prior to 1967.(15) These shortfalls in the capabilities of public sector shipyards would place the onus for most reactivation, repair and construction on large, private sector shipyards; it is the recent precipitous decline of these shipyards that is of most concern to mobilization planners.(16)

At first glance, the private U.S. shipbuilding and repair industry appears to constitute a formidable industrial plant (see Appendix A for a listing of active shipyards). Indeed, the capabilities of certain segments of the industry are awesome. For example, the Newport News Shipbuilding and Drydock Company has, at various times in the past few years, been engaged in the construction of two to three nuclear aircraft carriers simultaneously.(17) It is doubtful that there is another shipyard in the world capable of constructing even one such vessel, let alone several at once.(18) Unfortunately, the bright spots generated by the buildup to the Reagan Administration's goal of a 600-ship Navy cannot obscure the fact that the private sector of the

U.S. shipbuilding and repair industry is in serious trouble. The symptoms of this decline are multiple: decreasing numbers of shipyards, the collapse of domestic civilian shipbuilding, the concentration of U.S. Navy work in a small percentage of shipyards, a concurrent concentration of shipyard workers in a few shipyards, and the contraction of the shipyard equipment supplier base are the most striking.

Since 1982, the number of private shipyards in the mobilization base has declined from 138 to 116.(19) Of these yards, 24 are actively seeking to construct large, oceangoing vessels.(20) See Appendix B for a list of these yards. Correspondingly, the number of building and docking positions capable of accepting a vessel of 400 feet in length declined from 223 to 164.(21) It is unlikely that many of these closed yards could return to active service if economic conditions in the industry were to improve in the future. The combination of the ravages of the elements(22) and pressure to convert the industrial waterfronts of many American cities to light industry(23) and shopping districts make the closed shipyard a prime development candidate. In 1987, the city of Seattle unsuccessfully attempted to prevent the Lockheed Corporation from stripping its closed shipyard in that city. Within 12 months of closing, the shipyard equipment, including cranes and machine tools, had been

removed, with the loss of significant mobilization assets in the Pacific Northwest.(24)

The downward trend shows no signs of reversing itself. As of August 1988, 6 additional shipyards in the mobilization base were operating under Chapter 11 bankruptcy protection.(25) The demise of these shipyards would mean a loss of an additional 18 building and docking positions.(26)

The steep decline in the number of shipyards is not surprising in view of the current status of American merchant shipbuilding and ship repair. The building of oceangoing merchant ships in the United States has ceased completely. After the delivery of a 710-foot U.S. flag container ship from a Sturgeon Bay, Wisconsin shipyard in November, 1987, no merchant ships were being built anywhere in the United States.(27) By comparison, in 1980, 69 merchant ships were under construction in 15 U.S. shipyards.(28) This situation continues today. While some manufacturing industries might be able to diversify into other products when demand for the primary commodity decreases (or ceases altogether), the shipbuilding industry is another case, as noted by Mr. Henry Troger:

> The myriad skills and facilities used to construct a ship - the plant knowledge of naval architecture, production skills, and managerial talents - are of small worth if not being used

> to build ships. Though there are some exceptions, on the whole, shipyards cannot be converted to produce an alternative commodity and have little value unless there is a demand for the product. When product demand slackens, the talents and plants fade away.(29)

With the end, at least temporarily, of oceangoing commercial shipbuilding in the United States, all ship construction is Navy-related.(30) However, even this activity is concentrated in the largest shipyards. As of January 1988, 84 Navy vessels were under construction in 16 shipyards.(31) The six largest of these shipyards held 90 percent of the outstanding contract dollars.(32) This extreme concentration of shipbuilding business has put great pressure on the "second tier" shipyards, those smaller shipyards struggling for any construction work available. This has created an atmosphere of great and sometimes unrealistic competitiveness in the industry for the few available Navy ship contracts. While this may seem the best way to save the taxpayers money in building a Navy, some in Congress claim the Navy's awarding of construction contracts simply based on the lowest bid is contributing to the continuing industry decline. According to U.S. Representative Mike Lowry:

> The Navy by consistently awarding contracts to shipyards at costs below which a ship can be realistically constructed, creates an extremely

> competitive climate resulting in risks for shipbuilders and the potential demise of more shipyards. Although shipbuilders are aware of the risk posed by accepting a shipbuilding contract which will likely cost more to complete than the job will generate, many shipbuilders feel they have no choice but to compete for the few Navy jobs available just to keep their yards operating in hopes of better times in the future.(33)

While naval ship construction provides the largest single infusion of money into the shipbuilding and ship repair industry, it is the periodic repair and overhaul of Navy ships that effects the greatest number of shipyards. In fact, 1987 saw 86 percent of ship repair activity in private yards devoted to Navy work.(34) In 1987 the Navy ship repair base included eight naval and 48 private shipyards(35), with 31 private shipyards holding contracts for Navy overhauls and major repair availabilities as of January 1988.(36) See Appendix C for a list of these yards.

The U.S. Navy allocates a certain percent of overhaul and repair work for accomplishment in naval shipyards. This work includes extended, expensive, technologically challenging repairs of nuclear ships and other complex surface combatants.(37) Remaining Navy work is awarded on a competitive basis, strictly within the private sector, or between public and private sector shipyards. Private shipyards rely primarily on the overhaul and repair of these less complex vessels.

A major source of contention between the Navy and private shipyards has been the automatic allocation of certain work to naval shipyards. Private shipyards claim they could perform this work as well as Navy yards, which are being protected from competition by the government. In this atmosphere, the final split of public/private shipyard work is influenced significantly by politics; numerous congressional hearings have been conducted on how best to apportion Navy repair work, with still no definitive ruling.

Skilled Labor

The effects of the decline of the shipbuilding and ship repair industry can be illustrated by an examination of the current skilled labor base at work in America's shipyards.

For purposes of this thesis, skilled labor is defined as those production workers essential to the process of repairing and/or constructing ships. While over 50 shipyard job titles have been identified(38), 14 of these jobs, listed in Table 3-1 make up the vast majority of production workers and are most critical:

Table 3-1

Major Shipyard Skilled Labor Categories (39)

Electronic technician

Inspectors

Insulators

Loftworkers

Machine-tool operators

Machinists

Marine electricians

Marine pipefitters

Marine riggers

Painters

Sheetmetal workers

Shipfitters

Shipwrights

Welders

A description of these skills appears in Appendix D.

A demographic examination of the workers presents several interesting points. Shipyards remain a solid source of employment for minorities; blacks comprising 31.5 percent of the workforce.(40) Women comprise 10 percent of workers(41), almost the same share of the workforce as in 1944.(42) Educationally, 78 percent of workers hold at least a high school diploma, as compared to 73.9 percent of the entire U.S. population.(43)

As of January 1988, a total of 136,200 production workers were employed in U.S. shipyards.(44) This figure includes employment in all yards, including those with facilities too small to be included in the Shipyard Mobilization Base. A further breakdown of these figures in Table 3-2 illustrates the trend toward concentration of workers in the largest private and public shipyards:

Table 3-2

U.S. Shipyard Employment (1982-1988) (45)

Type Yard	1982 Employment (% of force)	1988 Employment (% of force)
U.S. Naval	39,500 (22.7)	33,000 (24.2)
5 Largest Private	57,500 (33.0)	57,600 (42.3)
Others	77,100 (44.3)	45,600 (33.5)
Total	174,100	136,200

As the above figures vividly depict, industry manpower, which has shrunk by 22 percent in six years, is moving into a handful of yards with steady Navy work. The decline in numbers has been geographically uneven, with employment in west coast shipyards falling off 51 percent in this period.(46) This phenomenon is generally attributed to higher labor costs on the west coast, which range two to three dollars per hour above those of the Gulf and Atlantic coasts.(47)

Two manpower problems potentially critical to the wartime mobilization of U.S. shipyards are evident even in the peacetime environment. First, the almost complete reliance on Navy work is occupying a large percent of production workers in the construction and repair of a small number of extremely complex naval combatants, such as aircraft carriers and submarines. In 1986, for example almost 40,000 workers were engaged in construction and repair of these nuclear vessels alone.(48) These workers, many with highly specialized skills, ply their trades in unit assembly shops working on extremely sophisticated equipment.(49) Their diversion to other, less complex projects, such as merchant ship construction or reactivation during mobilization may not be feasible, either from the standpoint of skills required or priority of work. This "fencing off" of workers due to their unique skills serves to reduce the pool of potential workers available to meet the more mundane aspects of shipyard mobilization.

The second condition present in shipyards is the difficulty in periodically hiring skilled workers to meet the large swings in employment demand prevalent in today's industry. The overwhelming reliance on one customer, the U.S. Navy, creates a virtual "feast or famine" atmosphere in many medium-sized private shipyards. Under these conditions, many skilled workers opt to transfer their talents to other industries, such

as construction. Thus, when demand for workers does increase in shpyards, employers, both public and private, are experiencing difficulty in recruiting. The Commission on Merchant Marine and Defense recently noted that this trend will continue to worsen, as the longer experienced shipyard workers are employed in a different industry, the less likely it is they will ever return to shiyards, in peace or war. Examples of manpower shortages abound. A survey recently conducted by the Shipbuilders Council of America indicated that of shipyards reporting, shortages of skilled labor were present in 17 to 50 percent of yards, depending on which occupation was sampled.(50) The average period of time the shortages had existed ranged from six months for painters, to 19 months for sheet metal workers.(51)

Results of a questionnaire prepared by this writer and completed by four private shipyards, located in such diverse locations as San Diego, San Francisco, Philadelphia, and Bath, Maine, indicate shortages of electricians, pipefitters, and welders to be common problems.(52)

A shipyard recently laid off 1200 workers, then attempted to rehire the same workers the next month for a new construction project; only 100 of the workers returned.(53) The National Vice President of the Industrial Union of Marine and Shipbuilding Workers of America, addressing the lack of skilled workers in

Baltimore, states: "When the shipyards close down you never get your skilled workers back. It's not just Baltimore. You cannot get the crafts anywhere because nobody is in training. I have people begging for welders in New York. We can't find them."(54) This problem is not only confined to struggling mid-size shipyards; Bath Iron Works, one of the Navy's most prolific shipbuilders recently had to go to great lengths to meet a surge in manpower demand caused by new orders. The company instituted a national hiring search for skilled workers, which is common industry practice. When this normal route failed to produce the required recruits, the company identified, hired and paid to relocate 35 unemployed copper miners from Montana to the Maine Shipyard.(55) These workers, many of whom possessed industrial skills readily adaptable to the shipyard, have performed superbly in their new jobs, and Bath is to be commended for its innovative approach to problem solving. However, the fact that the company had to reach 2,000 miles for a comparative handful of workers willing to relocate points out a fundamental problem. Few skilled workers are willing to freely move about the country in pursuit of transient shipyard work when more stable employment alternatives are available.

Even U.S. Naval shipyards are not immune. In 1987 the Navy advertised for electricians, shipfitters, and mechanics for 30 to 60 day temporary jobs at the Long

Beach and Philadelphia naval shipyards. After three months of no response, the Navy flew in over 100 Japanese and Filipino shipyard workers to perform the work. The resulting uproar caused the workers to be sent home, but Navy and labor officials alike agreed that hiring skilled American workers, who could make three to five dollars an hour more in private industry, would be difficult.(56)

Along with difficulties in recruiting skilled workers, shipyards face the problem of training inexperienced hirees. The cost, in time and money, of training workers to journeyman level in a shipyard, is high. This is illustrated in Table 3-3 by the hours of training time required to reach journeyman for certain skills:

Table 3-3

Hours of Training Required for Journeymen (57)

Skill	Training Time (Hours)
Shipfitter	8,000
Pipefitter	8,000
Rigger	8,000
Marine draftsman	10,000
Shipwright	8 to 10 years

It is estimated that the cost of replacing a skilled worker is between 25,000 and 30,000 dollars.(58) Clearly, given these high costs, it is not economically

feasible for most shipyards, with cyclic business dependent on one customer, to make the investment in training a worker to this level. For this reason, extended apprentice training programs, once prevalent in shipyards, are confined to the largest, busiest, private yards and naval shipyards.(59) According to the National Academy of Sciences, "Most shipyards, faced with the impossibility of meeting these training requirements, have adopted short-term, intensive training courses for trades in which turnover is most rapid, notably welders and shipfitters."(60)

This change in training emphasis could have both positive and negative implications for the shipyard industry's mobilization potential. On the positive side, programs for the rapid peacetime training of workers could be looked upon as valuable starting points for mobilization training programs. However, rapid training for intermittent employment will produce a worker not as skilled as a qualified journeyman. In time of mobilization, these workers might be considered the "cadre" for rapid employment expansion, and production and quality could potentially suffer.

A final group of shipyard employees merits discussion at this point. They are the management personnel who would be responsible for the orchestration of the great amount of planning and execution that would be required by shipyard mobilization. These personnel

include naval architects and engineers and line or operating managers.(61) Naval architects and engineers are typically graduates of naval architecture schools (such as the University of Michigan and MIT)(62) and are responsible for the design and engineering aspects of shipyard work. Line managers may have worked their way up through the shipyard organization, or be transferees from other branches of companies in shipyards owned by conglomerates (i.e. Tenneco, Litton)(63) They perform the vital function of supervising the work of the skilled trades. While these workers typically comprise only 15 percent of shipyard employees(64) they are a vital part of production in both shipbuilding and ship repair. While exact figures on employment trends for these workers was not found, the cessation of U.S. commercial shipbuilding is causing naval architects, engineers, and line managers to lose expertise in this segment of the industry.(65)

Shipyard Equipment Suppliers

As noted earlier, the modern process of shipbuilding involves external metal fabrication, followed by an installation of thousands of internal components including propulsion equipment, reduction gears, electrical and electronic equipment, shafting, propellers, deck machinery, and the basic commodities

such as steel plate, piping and tubing, valves, fittings, ball bearings, fasteners, and many others.(66)

Most shipyards have shifted gradually from a diversified manufacturing system to assembly facilities. Even Newport News Shipbuilding, one of the nation's largest shipyards, years ago stopped manufacturing reduction gears, turbines, and boilers.(67) In fact, fifty to sixty percent of the construction cost of a commercial vessel or Navy combatant is spent outside of the shipyard for the procurement of machinery, equipment, and materials.(68) These components are produced by a large number of shipyard suppliers, from small companies to huge industrial conglomerates. Geographic locations of major suppliers are depicted in Appendix E. In 1985 alone, Newport News Shipbuilding estimated it bought more than 250,000 separate items from approximately 3500 suppliers.(69) While this number of suppliers seems impressive, it is deceiving for a number of reasons.

First, not all equipment suppliers produce major items deemed critical to the building, repair, or reactivation of ships. A component or system that meets one or more of the following criteria is considered a "major item":

- Lead time of over 12 months
- Single or sole source
- Foreign source only

- Material shortages at lower level of manufacture (minerals, metals, subcomponents, etc.)
- Planned wartime usage rate far in excess of peacetime demand
- Low production capacity
- Impact on ship construction or repair schedules(70)

The majority of components meeting these criteria are the propulsion systems that drive the ship and the electrical systems for navigating, communicating,and in the case of Navy ships, fighting. The inherent complexity of these major components, involving gears machined to tolerances of a few thousandths of an inch, or electronics comprised of thousands of microchips, requires their manufacture by large industries. Due to foreign competition and simple lack of demand, the number of American companies that produce these major components has shrunk to very low levels. Areas of concern include:

- The segment of the supplier base that provides ship engines or "prime movers" (gas turbines, steam turbines, and diesel engines). There are currently only two suppliers of steam turbines, with one expected to consolidate and downsize in the near future. There is only one supplier of marine gas turbines. There is only one supplier of large marine diesel engines, and they do not currently manufacture the slow speed diesel engines frequently used in new commercial ships.(71)

- U.S. manufacturers of propulsion shafting have been reduced from three firms to two.(72)

- U.S. manufacturers of reduction gears are projected to decline from seven to two if only Navy work is available. The machine tools used in the production of these gears are available from European manufacturers only.(73)

- As of 1987, U.S. manufacturers are no longer able to build large direct-drive electric motors.(74)

- As of 1987, U.S. manufacturers no longer produce cold drawn seamless carbon steel tubing of four inch or greater diameter.(75)

Also of note is the varying degree of importance each shipyard supplier attaches to his relationship to a shipyard. As noted by congressional investigators, "For some suppliers, the shipyard is a key customer who takes priority, for others, the yard is almost a nuisance customer in terms of volume and dollar value of order and the technology required."(76) For many large, diversified manufacturers, the current small volume of shipyard business is simply not worth the cost of maintaining production capacity. Just as the cost of producing only one ship of a class is prohibitive, so is the cost of producing the specialized equipment that makes up the ship.

At a more basic level, the ability of American industry to produce machine tools - the equipment that

produces finely machined gears and other machinery - is eroding. Between 1977 and 1986, the foreign share of the American market tripled, from 16 to 49 percent.(77) This, coupled with the 50 percent reduction in U.S. steel making capacity since 1980(78) would be areas of serious concern in the event of mobilization.

While U.S. shipbuilding and ship repair industry is the focus of this thesis, it does not operate in a vacuum. It is only one of approximately 40 national shipyard industries scattered around the world.(79) The dynamics of this world industry have a profound effect on the current status of U.S. shipyards, and on consideration of any plans for additional assistance to the U.S. industry. As such, a short overview of the world industry today is offered.

Worldwide Shipbuilding and Ship Repair

In spite of the worldwide surplus of shipping tonnage, significant construction and repair of ships continues around the world. In 1985, 349 shipyards located on every continent were constructing 1600 vessels, excluding naval ships.(80) In 1986, 524 of these ships were completed and delivered.(81) A further breakdown of these statistics indicates the dominance of two countries in today's shipbuilding industry: Japan and South Korea. Japan's 245 and South Korea's 80 ship completions account for well over half of the 1985 total.

Also, the dramatic shift of the center of gravity of the shipbuilding industry from NATO and Northern Europe to the Pacific basin can be seen in Table 3-4.

Table 3-4

World Shares of Commercial Shipbuilding Market (1970-1986) (82)

Country	1970	1986
Japan	45.0%	36.8%
Sweden	8.0%	-
West Germany	6.0%	1.7%
Spain	5.0%	2.1%
United Kingdom	5.0%	1.2%
United States	3.0%	1.1%
South Korea	0.3%	15.9%
Taiwan	-	2.7%
China	-	2.7%
Others	27.7%	34.1%
Total	100.0%	100.0%

This trend can be attributed to a number of causes, including wage differential, superior technology, and levels of government support. A brief comparison of the Japanese and Korean industries to that of the U.S. in these three areas is instructive.

Even the most automated shipyard is a manpower intensive operation. This being the case, shipyard

business has tended to gravitate toward sources of "cheap labor". In 1984, shipyard workers in the world's fastest growing new shipyard power, South Korea, earned an average of two dollars per hour, slightly more than half the U.S. minimum wage, and a mere fraction of the 10 dollars per hour commanded by U.S. workers.(83) This disparity is multiplied by the fact that labor accounts for an estimated 45 percent of the cost of building a ship, and that U.S. shipyards required between 38 and 65 percent more manhours than Japanese or South Koreans to construct a comparable ship.(84)

This excellent labor productivity is due, at least partially, to the investments of Japanese and South Korean shipyards in state of the art production facilities. The Japanese shipyard industry, destroyed during World War II, and subsequently rebuilt, and the South Korean industry, built in the last two decades, boast facilities much newer than those of the United States. Production innovation in these Far East yards include computer assisted design (CAD), robotics, process lane technology, and preoutfitting.(85) Process lane technology is the categorization of work to allow employees at the same work station to perform the same function with the same organized flow of material.(86) Preoutfitting involves the installation of as many components as possible into "submodules" prior to being fitted into the hull of the ship.(87) These

technologies, used widely by large Japanese shipyards and increasingly by South Korean yards, are in their infancy in the U.S. industry.(88) In 1985 for example only three U.S. shipyards employed robotics.(89) Other techniques, such as process lane methodology lend themselves to the production of a series of ships of the same design. Given the collapse of U.S. commercial shipbuilding, only the handful of shipyards producing multiple ships for the U.S. Navy have sufficient work to make these technologies useful. Firms such as Newport News Shipbuilding, Bath Iron Works, Ingalls Shipbuilding, and Avondale Shipyards have made great strides in this area.(90) In fact, Avondale Shipyards recently entered into a technology transfer agreement with a Japanese shipbuilder (IHI) to aid in the computerized design and production of a series of oilers for the Military Sealift Command.(91)

Unfortunately, the U.S. firms listed above comprise less than 20 percent of the active shipbuilding base and only five percent of the shipyard mobilization base. Shipbuilding yards without significant Navy work are faced with a dilemma; not enough business to justify large modernization investment, but little chance of obtaining future commercial business without modernizing. This vicious circle is especially ironic when one considers that modular and series construction techniques were developed in the U.S. less than 50 years ago,(92) and largely discarded after World War II.

The success of Japanese and Korean shipyards, as well as the continued existence of most other private shipyards around the world can also be attributed to varying degrees of government support.

In the case of Japan, postwar government aid to shipyards has been in three basic forms: a planned shipbuilding program, preferential financing, and tax benefits.(93) Under the planned shipbuilding program, the Japanese government promulgates on a yearly basis the number and types of ships that are eligible to be built with government backed loans and subsidies.(94) This allows the government to exercise close control, within the limits of the program, over what types of ships are built in Japan. Preferential financing is available to domestic and foreign firms buying Japanese-built ships; the interest rate on loans is again largely determined by the type of ship being constructed. The most significant tax advantage offered by the Japanese government is a system of accelerated depreciation for purchases of specific types of ships.

Additionally, the Japanese government, through its Ship Research Institute, conducts and fosters research related to shipbuilding. Among other programs, the institute offers direct grants, low interest loans, and equipment support to firms researching in fields such as robotization and computerization.(95)

Over the last 40 years, the overall effect of government aid on the Japanese shipbuilding industry has been positive. From the ruins of World War II, Japan's shipyards have emerged as the world's most productive. Even Japan's industry has not been immune from the worldwide shipping glut of the past 15 years, however. In the late 1970's to early 1980's, for example, one-third of shipbuilding related jobs were lost in the industry.(96) As in the U.S., shipyard activity has been concentrated in seven major yards, which by 1982 produced 91 percent of total sales.(97) However, in contrast to the U.S., where Navy business now makes up 100 percent of new ship construction, the Japanese shipyards continue to produce a preponderance of civilian merchant vessels. Even as Japan was holding its position of shipbuilding primacy over the last two decades, a new power in world shipbuilding was rising rapidly: South Korea.

Shipbuilding in South Korea, until the mid 1970's limited to fishing and coastal vessels, was specifically targeted for development and expansion by the Korean government. This was due largely to the abundance of inexpensive labor available and the linkage of shipbuilding to other industries deemed worthy of expansion (steel, electronics, chemicals).(98) As this industry has been built quickly "from the ground up", government involvement has been substantial. The government has been the predominant force in research and

development, having established the Korea Institute of Machinery and Metals (KIMM) to assist in the advancement of shipyard technology.(99)

South Korean government involvement in financing has also been significant, including financing of up to 90 percent of construction costs for Korean ship owners and almost 60 percent for foreigners.(100)

While the shipyard industries of the Pacific rim have expanded over the last 20 years, the traditional European powers in the industry, including England, Sweden, and Germany have seen a precipitous decline in business. Once again, cost differential has proven the decisive factor in this decline. However, in contrast to United States policies of the last decade, European governments have continued to heavily subsidize their industries; in fact, the European economic community has recently agreed to approve government subsidies of up to 28 percent of shipbuilding costs.(101) While probably permanently relegated to second-rate status in terms of numbers of vessels and tonnage produced, west European shipyards, assisted by foreign technology, continue to doggedly pursue construction work, including export vessels. In this setting, West German yards, with government subsidies, are constructing five state of the art technology container ships for a U.S. flag shipping company. The ships are powered by diesel engines built in Korea.(102)

In examining the state of the world's shipyards, several trends are apparent. First, peacetime shipyard overcapacity is present in many parts of the world, including Europe and the Far East. Coupled with the worldwide shipping surplus, this ensures shipyard work in the near to mid-term will be awarded in a highly competitive atmosphere. The U.S. shipbuilding and repair industry, in order to compete, has to develop a more innovative approach, both towards updating the current physical plant and developing more creative financing and international joint ventures.

Another continuing feature of the world shipbuilding and repair industry is extensive government involvement and support. From research and development assistance to direct subsidization of construction, governments around the world continue to nurture and protect their shipyard industries. For its part, the U.S. government must examine its current support apparatus for U.S. shipyards, including the suspended CDS program, to determine if more support is prudent in the name of national defense.

In summary, the U.S. shipbuilding and ship repair industry in the last decade has experienced a period of profound transition, from an industry with private and Navy business to one overwhelmingly dominated by the Navy. This has meant a decline in the numbers of shipyards, workers, and equipment suppliers. The

Secretary of Defense himself stated that "Navy work alone could not maintain a diversified shipbuilding and ship repair industry capable of meeting all mobilization requirements in time of general war or national emergency."(103) With the end of the Reagan Administration's naval buildup and slowing in defense spending, this decline is likely to accelerate. In this context, the ability of the industry to meet the Department of Defense guidelines specified at the beginning of this chapter is in doubt. The next step in determining the industry's mobilization potential will be to detail the wartime demands that will be placed upon it, and its ability to respond.

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CHAPTER 4

THE WAR SCENARIO

Any examination of the adequacy of industrial resources for the defense of this nation must be preceeded by an understanding of the war scenario foreseen by U.S. government planners.

In the three decades after the last major industrial mobilization in World War II, the advent of the huge nuclear arsenals of the superpowers tended to drive defense planning in the direction of a "short war" scenario.(1) This short war, almost certainly culminating in a nuclear exchange between the Soviet Union and United States, would not be of sufficient length to stress the industrial base. Indeed, a person subscribing to this theory would likely disregard the need for extensive industrial preparedness beyond the scope of supporting existing forces and providing some surge production capability for small "brushfire" wars.

In the last decade, however, increasing emphasis has been placed on the requirement for the U.S. to fight and sustain a "long war" scenario. In fact, the latest scenario promulgated by the Department of Defense and Joint Chiefs of Staff in the Defense Guidance envisions a prolonged conventional war in three theaters, on a global scale(2), beginning in Southwest Asia, spreading into the NATO countries, Korea and three major oceans.(3)

The United States Navy would be active in all major oceans, securing sea lines of communication to allies and executing key aspects of the maritime strategy. The most intrepid feature of this strategy is surely "carrying the fight to the enemy" involving the placement of large numbers of ships in relative proximity to the USSR land mass.(4) Also within this scenario, the naval and merchant fleets of the U.S. will be required to provide two main categories of support to the national war effort. The first of these efforts would be strategic sealift. This category is comprised of the delivery of prepositioned materials, the surge of troops and equipment to a theater from CONUS, and the subsequent resupply of these forces.(5)

Of equal importance to the conduct of a prolonged war is the second main effort, economic support shipping. The U.S. manufacturing economy is critically dependent on the import of many strategic materials, beginning with the most basic component of industrial production, petroleum. In 1988, U.S. imports of petroleum topped 40 percent of total consumption. The vast majority of the millions of barrels of oil imported into this country each day travel by sea. In addition, the manufacture of military equipment and most durable goods in the U.S. is heavily dependent on imported minerals. Examples include chromium (75 percent imported) vital to metallurgy in

aircraft and shipbuilding, and manganese (100 percent imported) key to steel production.(6)

The translation of these general requirements into specific numbers of merchant ships needed is a risky proposition, subject to the intensity of conflict and availability of foreign ships. However, the U.S. Maritime Administration and Department of Defense have conducted several studies aimed at quantifying the number and type of ships needed, and the figures generally agreed on give a "feel" for what ships would be required during the surge and resupply phases of conflict. These numbers are detailed in Table 4-1.

Table 4-1

Sealift Requirements for Prolonged Conflict (7)

Ship Type	Military Support	Economic Support
Tankers	351 HSTE*	234
Dry	360	169
Bulk	-	204
Total	630	607

(*Note: Defense requirements for tankers are measured by "Handy Size Tanker Equivalents" (HSTE), defined as a 27,500 DWT tanker capable of carrying 200,000 barrels of POL. As a result, a larger tanker might fulfill the requirement for more than one HSTE.)

Once mobilization orders are given during a buildup in tension to the conflict described above, the Department of the Navy and the U.S. Maritime Administration will determine specific theater sealift requirements(8) and begin assembling their merchant fleet from a number of sources, including the Military Sealift Command, U.S. flag merchant ships, the Effective U.S. Controlled Fleet (EUSC), and Ready Reserve Fleet (RRF) ships of the National Defense Reserve Fleet (NDRF).(9) These assets are to be supplemented in the European theater by a 600-ship pool from NATO nations.(10)

The Military Sealift Command (MSC) operates 127 government-owned ships in the peacetime support of the U.S. defense establishment.(11) These include 24 ships, staged in locations around the world containing prepositioned stocks of war materials for U.S. forces to be deployed to distant theaters. Additionally, 41 ships operate in direct support of U.S. Navy ships, performing services such as towing, refueling, resupply, and surveying. The MSC fleet, while readily available, contains only 88 active ships that could be considered true sealift assets.(12)

The U.S. flag merchant fleet, as of July 1988, consisted of 409 ships, including 176 cargo ships, 203 tankers, and 26 dry bulk ships.(13) These vessels could be acquired by voluntary charter; through the Sealift Readiness Program (SRP) in which ships are previously

committed for contingency use; or through outright requisition, authorized by the President.(14)

The EUSC consists of merchant vessels owned by U.S. citizens but registered (flagged) in Liberia, Panama, Honduras, and the Bahamas.(15) Of these 289 vessels, 19 dry cargo vessels, 99 tankers, and 11 passenger ships would be militarily useful to support U.S. forces.(16) The other vessels could presumably be used for economic support. The legal authority of the U.S. government to requisition these ships derives from the Merchant Marine Act of 1936 and the laws of these countries do not preclude such U.S. action.(17) However, most crews of these vessels are foreign,and may not be automatically counted on to venture into hostile war zones. The issue of politics also arises; during the 1973 Arab-Israeli War, foreign crews operating U.S.-owned ships under the Liberian flag temporarily refused to deliver supplies to Israel on order of the Liberian government.(18) Recent political unrest in Panama also casts some doubt on the future trustworthiness of the EUSC flag governments.

This review now turns to the final source of emergency shipping rapidly available to the U.S. at the start of mobilization, the NDRF and RRF. Activation of RRF ships presents the key merchant shipping challenge to U.S. shipyards in the early stages of mobilization; as such, a detailed description is warranted.

The National Defense Reserve Fleet (NDRF)

The NDRF traces its roots to the lessons of World War II. The grievous losses inflicted on allied shipping by German U-boats in the early years of the war could not be replaced on a one for one basis; merchant ships were being sunk faster than they could be built. Not until the later phases of the war, through a combination of shipbuilding and anti-submarine warfare, could this equation be reversed.

At war's end, American planners realized that maintaining a fleet of merchant ships in inactive status, that could be called upon in a national emergency was a prudent national security policy. In 1945, the U.S. government owned over 5,000 ships(19), the vast majority built during the years 1940-45. Drawing from this huge array of assets, the National Defense Reserve Fleet (NDRF) was established in 1946.(20) Ships no longer required for active government service were towed to strategically located sites on the East, West, and Gulf coasts. At these sites, the ships were berthed in "nests" of several ships and "mothballed". The process of mothballing, or inactivation, involves the preparation and protection of a vessel for a long period of inactivity. The ships were sealed and dehumidified internally and rigged with cathodic protection to retard the growth of Marine life on the hull below the waterline.(21) From just five ships in 1945, the NDRF

grew to over 2200 ships in 1950.(22) During both the Korean and Vietnam conflicts the NDRF proved its worth. In the Vietnam War alone, 176 NDRF ships were broken out of nests, towed to shipyards, reactivated, and used to carry the huge volume of supplies needed half a world away.(23)

Today, the NDRF continues to play an important role in planning for U.S. sealift, although its numbers have shrunk dramatically. Due to the block obsolescence of the World War II Victory and Liberty ships which were the backbone of the fleet, its size has shrunk from 2277 in 1950 to 326 in 1987.(24) These ships are stored at three main locations in the U.S.: Suisun Bay, CA; James River, VA; and Beaumont, TX; and maintained by personnel of the U.S. Maritime Administration.(25) The ships are a diverse mixture with rspect to function, age, and utility. From a functional standpoint, the ships can be roughly broken down into three categories: (1) Tankers for the transportation of bulk petroleum products; (2) Dry cargo ships including "RO-RO" ships capable of rolling vehicles on and off and "Breakbulk" ships requiring cranes or other sophisticated port facilities to load or unload; and (3) Other classes of ships, including some former Navy tugboats and supply ships.

These ships are either: (1) Retained for national defense - these are the ships that would be useful for sealift in an emergency; or (2) Special program ships -

these ships have specific missions critical to national defense, but not in the field of sealift. An example would be the salvage ship, Glomar Explorer, currently laid up in Suisun Bay;(26) and (3) Scrap candidates - these ships have come to the end of their useful lives and reactivation would involve an inordinate amount of effort. They are to be broken out of nests and sold to scrapyards.(27)

The role of the NDRF is limited to its eventual use as attrition fillers to replace government or privately-owned ships of the U.S. merchant fleet damaged or sunk. Additional uses might be to replace ships of the U.S. merchant marine requisitioned by the government to meet heavy initial wartime lift requirements.(28)

Given the follow-up role envisioned for the NDRF, planning centered on beginning to introduce reactivated ships into the fleet from 20 to 60 days after mobilization.(29)

By the mid-1970's however, the decline in the active U.S. merchant fleet reached a stage at which defense planners identified a need for a force of ships within the NDRF that could be activated more quickly to serve as transports in the initial "surge" phase of conflict. In response to this requirement, the Ready Reserve Force (RRF) was established in 1976.(30) From an initial force of 30 ships(31), the RRF has grown to a 91 vessel "subset" of the NDRF. Data on RRF ships is found

in Appendix F. The ships comprise the most modern vessels in the NDRF and include both special purpose and tanker/cargo ships.

The ships are categorized for activation within 5, 10, or 20 days of mobilization.(32) RRF ships are berthed at the three NDRF sites, as well as many "layberths" in various ports.(33) The purpose of layberthing is to place the RRF ships at piers as close as possible to reactivation shipyards to minimize the delay in breaking out and towing. RRF ships undergo more intensive regular maintenance than the remainder of the NDRF, including drydockings for hull cleaning and repair every five years.(34) An additional investment has been made in the installation of Sealift Enhancement Features (SEF) on most units in the RRF. SEF features include helicopter facilities, at sea refueling capability, vehicle tiedowns and storage space for lighters on deck designed to make these ships more useful in a military role.(35) However, these installations are by no mes complete on all RRF ships. In fact, the completion of needed SEF work would be required during the reactivation of many of these ships.(36)

The Maritime Administration has the responsibility of maintaining the NDRF, including the RRF. However, due to the increased maintenance and readiness requirements of the RRF, more detailed arrangements have been established with private contractors. The Maritime

Administration has contracted for routine maintenance, and when necessary, reactivation of RRF ships with private shipyards. These "ship managers" have been selected on a competitive bid basis and are listed, for each RRF ship in Appendix F.

To test the ability of MARAD and contractors to reactivate RRF ships, seven exercise activations were held in FY 1987. These exercises, involving the actual reactivation of ships for at-sea exercises, were conducted on East, West, and Gulf coasts. All seven reactivations were completed within time limitations.(37) However, in only one instance was the reactivation of more than one vessel in a specific geographic location attempted.(38)

The above categories of ships, comprising approximately 1000 hulls constitute the existing U.S.-owned assets that have the potential to be mobilized relatively quickly to support the military and national economy in the event of war. As previously mentioned, augmentation of these shipping assts is promised by our NATO allies. However, the ship total in merchant fleets of these countries has also declined dramatically in the last two decades, from 2,400 in 1970 to 1,600 in 1985 to 1,100 in 1987.(39) Any NATO contribution to U.S. military reinforcement efforts would also be subject to competition with national interests of the countries involved. Our European allies are heavily dependent on

imports of energy, raw materials and food to sustain their economies and populations. These requirements would have to be met, and in some cases increased, during global conflict. Political considerations driven by these facts could significantly restrict the numbers of NATO ships supporting U.S. efforts in Europe. This accelerating trend is ominous in its implication for allied sealift and resupply of Europe.

This decline in peacetime sealift assets, coupled with merchant ship losses expected due to hostile action, strongly implies that efficient production of new merchant ships will likely be crucial to the successful outcome of any future protracted conflict.

With these factors in mind, this thesis will now address the U.S. government's specific mobilization tasking to shipyards, and the latest estimates of the industry's ability to comply.

Shipyard Mobilization Tasking

As currently constituted, the U.S. government's mechanism for mobilization planning and execution is not concentrated in a central authority. While the Federal Emergency Management Agency (FEMA) is nominally the director of mobilization preparations, its main function is to coordinate, with NSC approval, efforts of 27 different departments and agencies with emergency planning functions.(40) The Department of the Navy (DON)

and U.S. Maritime Administration (MARAD) are responsible for mobilization planning related to the maritime industries, including shipyards. This industrial planning is done within the framework of the effective titles of the Defense Production Act of 1950, which allows the government to designate defense related production industries top priority for assets, provides financing to expand production capability, and establish additional organizations to track industrial mobilization if necessary.(41) As of 1988, the following tasks are to be accomplished by the U.S. shipbuilding and ship repair industry in a full-scale mobilization:

1. Accelerated completion of ongoing maintenance and repair.
2. Ongoing new construction.
3. Reactivation of the RRF.
4. MARAD mobilization new construction.
5. Navy mobilization new construction.
6. Battle damage repair.
7. Reactivation of the NDRF.
8. Reactivation of ISNAC ships.(42)

The Department of the Navy and Maritime Administration have established sets of notional planning factors to be utilized in the measurement of industry capabilities in the eight areas listed above. These factors are used in the Naval Sea Systems Command's ALIAS

computer model, which manipulates ship construction and repair schedules while considering a wide range of environmental inputs.(43) Outputs of this model, addressing shipyard capacity, will be discussed later in this thesis. The salient planning inputs to each task follow. In examining these inputs, it is interesting to note the changes in relative importance of the three shipyard components, facilities, manpower, and equipment, to the successful completion of each task.

Accelerated Completion of Ongoing Maintenance and Repair

While the exact numbers and types of ships vary, the number of U.S. Navy ships requiring regular maintenance and repair on a given date can be accurately forecast. For purposes of this thesis, the total is assumed to be approximately 90 ships during the scenario timeframe.(44) Upon mobilization, a decision will be made by the Navy based on percentage of repairs completed, as to which vessels in a maintenance status are to be immediately returned to service and which are to be repaired at an accelerated rate. As a general rule, ships on which maintenance work is less than 15 percent completed will be restored to operating status and returned for service; maintenance on other ships will be accelerated to allow completion in approximately 60 percent of scheduled time.(45) Although no new repairs will be scheduled for conventionally-powered Navy vessels

until M+12 months, overhauls and refueling of nuclear powered vessels will be accomplished as previously scheduled.(46)

Acceleration of work implies the addition of new workers and possibly the creation of additional shifts, with some of the additional manpower demand met by workers released from ships restored and returned to the Navy. As these vessels will already occupy the shipyard positions, no extra load will be placed on the physical plant. From the standpoint of equipment suppliers, the acceleration will present a challenge. Many sophisticated pieces of equipment, particularly electronic gear, are removed from Navy ships in a repair period and shipped to the manufacturer, often thousands of miles away, for refurbishment. These firms often operate with a small manpower base and a tight schedule. To demand a rapid acceleration of repair activities from these companies certainly poses a significant potential for bottlenecks.

RRF Reactivation

The reactivation of RRF ships is the critical task facing U.S. shipyards in the pre D-Day phase of the conflict. These ships, expeditiously reactivated and crewed, would be pivotal in moving supplies during the "surge" phase. Current planning calls for the towing of these vessels from NDRF or lay up sites to predetermined shipyards for reactivation, beginning with 5-day ships,

then 10-day, and finally 20-day ships.(47) Upon arrival at shipyard sites, the ships would be berthed and reactivation commenced. Due to the periodic maintenance currently being conducted on these ships, drydocking is not required in the reactivation package. In fact, some of these ships, located at layberths with sufficient services available, could be reactivated on-site, without towing.(48) The reactivation package is estimated to require approximately 1100 man-days to complete; this translates into slightly over 200 workers, including electricians, welders, machinists, pipefitters, sheet metal workers, and shipfitters working five days to completion.(49) Tasks to be performed include preparation and testing of ships propulsion and electronics systems, as well as installation of any desired Sealift Enhancement Features.(50)

This task of shipyard mobilization involves relatively light demand for specialized shipyard facilities (i.e., drydocks), and as these ships are almost completely equipped, little additional demand for critical component equipment is projected. What is required is skilled manpower, ready to step in immediately and perform trade tasks on a variety of different merchant ship types. In the first days of this effort, there will be no time for training new employees. The labor base currently working or residing in the area will have to fill the bill.

NDRF Reactivation

Following activation of the RRF, similar actions will be taken to return to service the 135 remaining NDRF ships considered useful for economic support or backup military support. These vessels are to be reactivated in the time period stretching from M+6 weeks to M+7 months.(51) The physical condition of these ships is considerably worse than RRF ships, and as such the number of man-days required for reactivation is over five times that for the RRF. Additionally, a drydocking period of several days is required for hull work.(52) Reactivation of these ships will not only place a greater demand on shipyard facilities than the RRF, but the advanced age of most of these ships means that the workforce needed for reactivation will be different than that required for the RRF - larger, and with more expertise in repairing steam propulsion equipment, as opposed to the diesels commonly found in the RRF.

The age and long period of inactivity of these ships also suggests that the replacement of some items of equipment may be required during reactivation. The supplying of equipment for old ships with obsolete propulsion plants will present an additional challenge to the supplier base.

Battle Damage Repair

This aspect of mobilization planning is certainly the most difficult, at least from the standpoint of

predicting numbers of ships damaged and component equipment requiring repair or replacement. It is in this task that the ALIAS system provides the most critical, computer generated planning factors used in shipyard mobilization assessment. The most important of these planning factors are:

(Navy)

- A minimum of 10 percent of the naval fleet will be damaged, sunk or lost during the first six months of a global conflict. This will drop to 5 percent during the next six months and 2.5 percent thereafter.

- 67 percent of Navy ships hit will sink or be damaged beyond repair.

- All damage to surviving damaged ships is severe and considered repairable.

- 62 percent of battle damage repair will be done in CONUS; the remainder performed by U.S. Navy repair ships and bases overseas.

- Type of damage (hull or topside) is randomly assigned.

- Hull damage requires 50 percent of yard days in drydock.

- Topside damage requires 20 percent of yard days in drydock.

(Merchant)

- 12 percent of all merchant ships supporting military operations or economic support requirements will be damaged, sunk, or lost in the first month of a global conflict. This will drop to three percent in the second month, two percent in the third month, and one percent thereafter.

- 50 percent of merchant ships hit will be sunk or damaged beyond repair.

- Of the 50 percent of the ships hit and requiring repair, all will require shipyard support.

- Repair of U.S. ships in foreign shipyards will be offset by the requirement to repair some foreign flag ships in U.S. yards.(53)

Planning calls for battle-damaged Navy ships to be assigned to naval shipyards with the ability to perform repairs on the complex combat systems involved. Damaged merchant ships will be assigned shipyards with requisite repair capabilities.(54)

Reactivation of ISNAC Ships

Inactive Ships in Navy Custody (ISNAC) are located at four primary sites: Puget Sound Naval Shipyard in Bremerton, Washington; Philadelphia Naval Shipyard; Pearl Harbor Naval Shipyard; and Portsmouth, Virginia.(55) These vessels include four aircraft carriers, two heavy cruisers, 10 destroyers, and five amphibious assault ships. These vessels have been in an inactive status for

three to 20 years. Planning calls for the reactivation of these vessels at the nearest naval shipyard commencing on D-Day.(56) Owing to the advanced age of these vessels, the requirements in time and man-days to reactivate are substantial. The destroyers are estimated to require 69,500 man-days stretched over 132 workdays, the cruisers 256,000 man-days over 256 workdays, and the aircraft carriers about 1.5 million man-days over 20 months.(57) The ships will require drydocking, and will generate significant demand for replacement equipment during reactivation, as many have been stripped of electronic equipmient and what remains onboard is largely obsolete. In fact, the returns from the reactivation of these vessels may not be sufficient to justify the investment in manpower and facilities, especially in the case of the carriers.(58)

Ongoing New Construction

This category is comprised of approximately 90 Navy ships, under construction or contracted for prior to D-Day. The goal is to complete these vessels in 67 percent of previously planned time.(59) As with ongoing maintenance, this will add a minimal additional load to shipyard facilities, as these vessels already occupy a building position or are programmed to do so. The significant additional demands will be in the area of increased manpower, and shortened required delivery times for component equipment.

Mobilization Construction

As the battle damage numbers above suggest, the attrition factors for both Navy and merchant vessels will be significant. In a war lasting at least four years, the need to replace these ships will be critical, perhaps essential to continuing the war effort.

The construction of mobilization vessels, both Navy and merchant, authorized after M-day will be a major task of private shipyards during the sustaining phase of operations. This work will be conducted in concert with repairs to battle-damaged ships, as required.

Current Navy planning calls for the construction of 240 new warships during the four-year mobilization period, including combatant and support vessels.(60) Construction of combatant ships (aircraft carriers, cruisers, destroyers) will take priority over amphibious and support shipping, and Navy construction as a whole will take priority over merchant construction.(61)

The construction of merchant ships will be driven by MARAD guidance. MARAD, in concert with the Navy, has identified the need to build 250 new ships in the four-year mobilization period. These ships would include 170 general cargo and 80 tanker ships.(62) MARAD specifications for these ships are detailed in Table 4-2.

Table 4-2

Characteristics of MARAD Mobilization

Construction Ships (63)

	Multi-Purpose Cargo	Handy-Size Tanker
Design	C9-S-MA134a	T6-M-98a
Type	Breakbulk/Combo	Product Tanker
Length Overall	723.5 ft	711 ft
Beam	105.5 ft	84 ft
Draft (Max)	35 ft	34.4 ft
Total DWT	22,000 T	35,100 T
Crew Size	35	26
Propulsion	Steam*	Med speed diesel

*NOTE: Due to the small manufacturing base for steam components and the obsolescence of steam as a merchant propulsion system, NAVSEASYSCOM planners envision all merchant ships will be powered by diesels. This underscores the fact that differences persist between agencies as to the specifics of these "mobilization ships."

As building positions capable of accommodating ships of this size are exhausted, MARAD plans to schedule the construction of smaller ships, 600 then 500 feet, until the complete run of 250 ships is scheduled.(64) The time planning factor for construction is 14 months, for 700 ft vessels, and 12 months for 500 and 600 foot vessels.

It is this task, the construction of almost 500 new ships, that presents the greatest challenge to the shipbuilding and ship repair industry. Over 48 months, the industry will be required to provide 490 building positions capable of supporting the early stages of ship construction. While a ship will not occupy a position for the entire time of construction, the lack of sophisticated modular construction facilities in most shipyards will require that ships be in building positions for longer than the mass-produced vessels of World War II. A dramatic increase in shipyard employment is also forecast. It is estimated that the skilled labor force will have to expand by 77,000 workers by M+18 months to meet the demands of new ship construction alone.(65) The demand on the equipment supplier base will be the most dramatic in terms of overall increase, however. The construction of 240 Navy vessels over a four-year period represents an approximately threefold increase over peacetime levels, and the construction of 250 merchant ships will be supported by a domestic industry which has not supplied equipment for new U.S.-built vessels in over two years.

With the above tasks in mind, this thesis now returns to the three key elements of the shipyard equation: facilities, manpower and equipmient suppliers, and the ability of each of these components to support the scenario.

Shipyard Facilities

The requirement for shipyard facilities varies as the scenario progresses and the mix of work changes. Reactivation of RRF ships and repair of vessels that have suffered damage above the waterline will generally require only that the ship be berthed at a pier within the shipyard, ideally in proximity to workshops and with access to cranes to lift heavy equipment. ISNAC and NDRF ships, due to their physical condition, require drydocking, which involves complete removal of the ship from the water, to accomplish repairs to the hull and its openings or to propulsion equipment (i.e., propellers and rudders.) Battle-damaged vessels having suffered torpedo or other hull damage will also require this service. Shipyard drydocks available to perform these functions are of two basic varieties. Graving drydocks are built into the shore as permanent facilities; ships are positioned in these docks, a gate is closed and the water pumped out of the dock. Floating drydocks, in contrast are moveable structures that are partially "sunk" to allow a ship to be precisely positioned over them, then pumped to the surface to lift the ship from the water.(66) Additionally, several shipyards possess marine railways and synchrolifts, designed to mechanically remove ships from the water for repairs.

Facilities for the construction of vessels are also of several varieties. Inclined shipways, familiar

to anyone who has watched films of World War II shipyards, remain a significant asset for construction. However, more capacity today resides in graving docks and floating drydocks.(67) In many large shipyards, such as Litton and Newport News, the use of building docks optimizes the advantages gained from modular construction techniques.(68) Also available for construction are a smaller number of synchrolifts and marine railways. Actual numbers of berthing, drydocking, and building positions available have been computed by Navy and MARAD planners in accordance with the guidelines stated in earlier mobilization planning.

Approximately 415 shipyard berths with depths of at least 12 feet, including piers, wharfs, and mooring dolphins, are capable of accepting a ship at least 400 feet in length, with a beam of 68 feet.(69) Almost 200 of these berths will accommodate ships greater than 700 feet in length.(70) This number will support all berthing requirements envisioned in the reactivation of RRF ships and non-drydocking phases of NDRF and ISNAC reactivation, as well as topside repair of battle damage.(71)

To support the drydocking requirements inherent in the reactivation and repair process, the shipyard mobilization base comprises 66 graving docks and 52 floating drydocks capable of accepting oceangoing vessels.(72) Due to the high priority assigned to

reactivation and battle damage repair, these ships will top the list for loading in drydocks. As previously noted, naval shipyards will not be involved in new vessel construction, and as such their extensive drydocking facilities will be dedicated to reactivation, battle damage repair, and scheduled maintenance of Navy ships. Given these facts, there are sufficient facilities to meet drydocking, reactivation, projected battle damage repair, and maintenance taskings.

The final general category of tasks is construction, including accelerated completion of ongoing Navy ships, as well as subsequent Navy and MARAD mobilization construction. Navy ships under construction at the time of mobilization already occupying building positions do not pose a capacity problem; as has been previously discussed, these ships are being constructed in a handful of large, sophisticated shipyards, in many cases with facilities designed specifically for series construction of Navy ships.(73) However, this ongoing construction will have an impact on the commencement of the Navy mobilization building program. This most complex and demanding requirement must be met by a small subset of the shipyard mobilization base; under current scenarios, Navy and MARAD plans call for construction to be conducted in only 29 private shipyards.(74) These yards are considered of sufficient size and sophistication, with the potential to greatly

expand workforces to meet the demands of construction. These shipyards contain 102 building positions,(75) capable of supporting mobilization building, including shipways, building drydocks, Marine railways, and land levels. The sequential loading of these positions, as depicted by the ALIAS model, would be determined by assigned priority (Navy combatants, then Navy support ships, then MARAD vessels) as well as the yards' ability to construct vessels of varying complexity. It is likely shipyards currently constructing a certain class of Navy ships would receive additional orders for similar mobilization ships to capitalize on their experience, while other shipyards capable of construction currently surviving on repair work alone would receive the significant MARAD mobilization orders.(76)

According to Navy and MARAD analysis, the current shipyard base is unable to provide the "laydown" capacity (the number of building positions) required to support mobilization construction requirements.(77) Even when efficiently loaded by the ALIAS computer, the keels of only 175 of 240 Navy ships and 98 of 250 MARAD ships can be laid down in shipyard building positions prior to the end of the 48 month mobilization period.(78)

This 44 percent shortfall in mobilization construction laydown capacity is certainly a troubling statistic. However, it is only truly critical to the shipbuilding program if it can be shown that this factor

would constrain the production rate supportable by skilled labor and the equipment supplier industry. With this in mind, an assessment of the labor situation follows.

Shipyard Manpower

In light of huge employment surges accomplished during this century, the ability of shipyards to rapidly hire and train large numbers of workers is often assumed as given. However, employment trends in the peacetime industry cast grave doubts on these assumptions.

Before examining planned shipyard manpower requirements, a review of employment issues and variables is offered. First, rehiring of previously laid off workers has not been successful in the recent peacetime environment. From 1982 to 1986, almost 53,000 U.S. shipyard jobs were lost;(79) many of these skilled workers have undoubtedly moved to profitable employment in other sectors of the economy, including the construction industry, which has boasted higher average hourly earnings for the last two decades.(80) Second, if the outlook for skilled labor rehiring is cloudy, so too is the possibility of hiring tens of thousands of inexperienced workers in World War II fashion. The World War II expansion was accomplished due to a number of factors: use of women, minorities, and farm workers, the lure of relatively high wages, and the high unemployment

rate that persisted in the late 1930s. With women and minorities strongly represented in the workforce, farm employment minimal, and unemployment low, the social and economic factors of today appear to work against a replay of the miracle of World War II hiring.(81)

Finally, most available figures for shipyard manpower requirements are general groupings, by coast, with no breakdown by specific shipyard or skill. Studying these aggregate figures will support a general conclusion, but cannot account for shortfalls of specific skills required in certain yards, or for the growing immobility of skilled workers.(82)

With these facts in mind, current estimates for required shipyard manpower will be reviewed, along with Navy, MARAD, and Commission on Merchant Marine estimates of manpower expansion potential. This thesis will also cite a statistical analysis of east coast shipyard manpower during the first 90 days of conflict, conducted by CDR Alan Katz at the U.S. Naval War Collegein 1988. This analysis consisted of a comparison of existing shipyard employment figures by trade with a three percent monthly growth factor, against notional man-day requirements for reactivation repair, ongoing construction, and new construction start up.(83)

Beginning with the mobilization order, U.S. shipyards will support the surge phase of conflict from M-Day to D-Day plus 90.(84) In this phase, characterized

by intensive reactivation activity, battle damage repair, and acceleration of ongoing repair and construction, shipyards will rely heavily on the existing workforce, with a one to three percent monthly expansion of manpower commencing at M-Day.(85) The roughly 50,000 shipyard workers not currently engaged in nuclear work,(86) plus additional hires, will be the key to success or failure in this phase. The Commission on Merchant Marine and Defense, after an analysis of manpower on each coast, concluded projected aggregate employment would be sufficient to accomplish surge phase taskings on all coasts.(87) However, shortfalls in several key shipyard areas were viewed with concern, and identified as having the potential to delay accomplishment of work during the surge phase. Of specific concern to the Commission were the Norfolk and San Francisco areas. Norfolk would suffer manpower shortfalls due to the large amount of ongoing work; ironically, San Francisco's shortfall stems from the opposite reason, a lack of peacetime work. These projected shortfalls are especially significant in that Norfolk and San Francisco shipyards will receive 29 RRF ships for reactivation early after M-Day.(88)

These difficulties projected by the government are mirrored in CDR Katz's analysis of east coast shipyards. His analysis suggests that within the first three months of mobilization, skilled labor shortages of 3.2 to 14.3 percent would exist in the overall east coast pool of

shipwrights, shipfitters, machinists, and electricians.(89) For private shipyards involved heavily with NDRF reactivation and ongoing construction, shortages of up to 64 percent for boilermakers, 45 percent for machinists, and 78 percent for shipwrights were derived.(90)

As the surge phase ends and the sustaining phase begins at D-Day plus 90 days, the demands of new ship construction will increase the demand for newly trained workers, many with no previous experience. The Commission on Merchant Marine and Defense estimates that by M-Day plus 12 months, 31,000 new workers will be needed, including 7,000 on the east coast, 11,000 on the west coast, and 10,000 on the Gulf coast.(91) This hiring curve steepens after M+12 months, with an additional 46,000 workers required in the six months culminating at M+18 months.(92)

A monthly growth rate of between five and 10 percent would be required on all coasts to support these manpower levels. While World War II expansion rates were in this range,(93) the ability of today's industry to support these figures in light of recent hiring difficulties is suspect. Given the current employment situation and demands other industries and the military would place on the population, recruiting trainable individuals for an industry involved in gearing to mass production would be a formidable challenge. The decline

in experienced manpower and apprentice training programs also suggests rapid expansion of a small workforce will reduce productivity in the short run due to a reduction in work quality.(94)

One indication of current government thinking on workforce expansion is the Navy's Production Base Analysis. While this document focuses mainly on production of ship components, planning estimates for workforce expansion are included, and provide the personnel input to the ALIAS computer model described earlier. The ALIAS model for new construction is based on either a one or three percent monthly employment increase, felt to be more realistic expansion goals. Based on a three percent monthly increase, 69 percent of 29 key shipyards modeled would experience labor shortfalls which would leave shipyard facilities underutilized. At a one percent monthly increase, 90 percent experience shortfalls.(95)

To summarize, shortages of skilled manpower will be present in both the surge and sustaining phases of mobilization. During the surge phase, the problem centers around certain skills and certain geographic areas. By contrast, the difficulty in the sustainment phase is the significant, across the board expansion of workers in all trades. Studies reviewed indicate shipyard employment cannot rise at a rate sufficient to fully utilize available shipbuilding facilities. Whether

this fact will be the key determinant of the "bottom line" of shipyard performance depends on an examination of the final element of the shipyard equation: the equipment suppliers.

Shipyard Equipment Suppliers

The ability of shipyard equipment suppliers to meet the demands of mobilization varies widely as the scenario progresses through the eight stages listed above. Before examining specific shortfalls, a brief discussion of three possible problem areas is offered. The areas that will directly effect industry performance are: availability of skilled manpower, access to required machine tools, many of which are of European manufacture, and the prioritization of Navy/MARAD orders in relation to other defense work.

While not a focus of this thesis, a sufficient skilled manpower pool is essential to thousands of manufacturing firms supporting shipyards in an attempt to ramp-up production and maximize plant capacity. In a 1987 survey conducted by NAVSEASYSCOM of over 1000 companies manufacturing electronic combat systems equipment, fully one-third of respondents reported shortages in engineering, technical, and skilled trades.(96) In companies producing hull mechanical and electrical (HM&E) items for ships (i.e., pumps, bearing) 25 percent indicated skilled labor could be a problem

during mobilization.(97) The electronic combat systems industry is currently operating at approximately 70 percent of capacity, and the hull, mechanical, and electrical (HM&E) industry at 61 percent.(98) In this climate, many companies experience the same problems with hiring and training as shipyards.

Recently, the National Machine Tools Builders Association of America stated "...in its present condition the U.S. machine tool industry could not sustain U.S.defense requirements should we become involved in a global conventional conflict of extended duration. America's experience and historical data indicate that when the domestic machine tool industry is weak, effective military mobilization is delayed for many months and these delays would directly and gravely impair the national security of our country."(99) The decline in the U.S. machine tool industry is manifested in several ways, including: Major U.S. manufacturers of gas turbine engines, propellers,and shafting expressing concern over the availability of spare parts for their foreign equipment in wartime; and lack of U.S. peacetime capacity to fabricate state-of-the-art hardened and ground reduction gears for sophisticated combatant ships resulting in their manufacture overseas.(100) One reason for the decline in the industry is similar to that mentioned for lagging shipyard technology -lack of sufficent demand to warrant the large investments

required for the new, competitive technologies. The reliance on foreign manufacturers of machine tools, many located in the potential battleground of Central Europe, is a major cause for concern.

The global war postulated will involve all U.S. armed forces, and as such mobilization production will support the entire Defense Department. In this context, Navy and MARAD orders may be subject to prioritization and possible delay, especially for items manufactured by a sole source filling orders for several customers. This is especially true in the radar, communications, and steel industries.(101)

While these considerations are difficult to quantify in numbers of ships built and repaired, the U.S. Navy and MARAD have conducted an extensive survey of electronics and HM&E manufacturers to determine mobilization potential based on plant capacity; the results, when compared to demand, give a good estimate of production versus requirements.

During the completion of ongoing construction, reactivation, and battle damage repair phases, the equipment supplier base is capable of supplying the equipment requirements of the shipyards.(102) This is due to the relatively light demand for new equipment in reactivations, and the presence of equipment already "in the pipeline" for the completion of ships under construction. While battle damage repair requirements

are subject to significant change, the accomplishment of these repairs are of high priority. Unexpectedly high damage rates would result in the diversion of newly manufactured equipment to repair, vice mobilization construction.

It is in supplying the almost 500 mobilization construction ships that serious shortfalls appear in the equipment supplier base. For Navy ships, several critical combat systems, some produced by sole source manufacturers, cannot be produced in quantities sufficient to support the 240 ship program.(103) Overall, 72 of the 175 ships laid down for construction during the four-year period would be undelivered at the end of this period due to equipment shortfalls.(104) MARAD merchant construction, occupying second priority behind the Navy, fares even worse. The crucial delaying factor in delaying MARAD vesselsis diesel engines. Over the four-year period modeled, domestic production of diesel engines will support production of only 18 of 98 merchant vessels laid down.(105) In addition, the domestically produced engines contain two critical components, turbochargers and crankshafts, manufactured by foreign companies. Loss of these suppliers reduces U.S. engine production capacity to zero.(106)

These figures are based on maximum expansion of existing facilities and manpower. During a mobilization, necessity would drive development of more production

facilities and more efficient production methods to increase output. However, as in the past, these wartime improvements would take precious time and scarce resources to achieve.

Summary

The U.S. shipbuilding and ship repair industry would be able to substantially support the reactivation, battle damage repair, and ongoing construction requirements of the war scenario. This process would not be easy, and projected shortfalls in manpower would demand close government coordination of scheduling and possibly transportation of critical workers to distant shipyard locations. Although delays in scheduled completions may be encountered, these are minimal when compared to the sustaining phase.

The projected construction of 490 ships during the sustaining phase cannot be supported by any component of the shipyard industry. Although shipyards can only lay down 56 percent of required hulls,(107) this is by no means the most critical shortfall of the industry as it is presently constituted. The equipment supplier base is able to provide all required components to only 44 percent of the ships that can be laid down.(108) At a three percent monthly growth rate, the manpower pool can generally support over 90 percent of shipyard capacity work, and is not a constraining factor when compared to

equipment shortfalls.(109) At a one percent growth rate, however, the manpower pool will become the driving factor in the non-accomplishment of shipyard work.(110)

These figures again underscore the key interrelationship between facilities, manpower, and equipment. The fact that all of these "key players" have suffered recently suggests that implementation of effective initiatives designed to assist shipyards will resultin the improvement of all three areas. Chapter Five contains recommendations for future action in this regard.

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CHAPTER 5

RECOMMENDATIONS AND CONCLUSIONS

Recommendations for Future Research

This research has addressed a large number of issues, historical and contemporary. The aim has been to produce a thesis highlighting a potentially serious shortfall in U.S. warfighting capability at the strategic and operational levels. While the research conducted supports the conclusions, many areas touched upon would lend themselves to further research.

Probably the most critical issue confronting any military officer planning for protracted war is sustainability. The shipyard mobilization base is but one facet of the larger area of industrial preparedness. A paper dealing with other aspects of strategic mobility and sustainment, such as airlift or defense industrial production, as they relate to the U.S. military's current force structure would be most revealing.

A topic addressed in this thesis, availability of skilled manpower, would also be a fitting subject for a more detailed examination in a future thesis. While CDR Katz's study is an excellent treatment of east coast shipyard workers, an expanded study of manpower availability for the entire national defense industrial base, including shipyards, would be an important work.

Returning to the specific area of shipyards, a very interesting research question might involve the long-term potential to revitalize the industry by technological innovation. Could government and private industry cooperate in the design and construction of a class of merchant ships that would, thanks to technological breakthrough, possess the speed and capacity to restore 21st century American shipyards to the primacy of the 1840's? The U.S. government is currently gearing up for a crash program to encourage American development of high definition television, substantially for reasons of national defense. It would seem that a similar investment in the basic means of transportation for the majority of our military forces is prudent. A study in this area might produce compelling conclusions.

Conclusions

It is difficult to select the one most striking fact concerning the U.S. shipbuilding and ship repair industry brought out in the course of this research. However, in reviewing written accounts, statistical data, and the statements and writings of government and industry leaders, five major conclusions accrue.

First, shipyards have been an important part of this nation's economic history since the early seventeenth century. During their history, U.S.

shipyards have enjoyed periods of international competitiveness and prosperity, but the twentieth century has seen these shipyards survive largely through government support, in the form of ship orders and favorable laws. This government support paid handsome dividends, however, in the last prolonged global war waged by the U.S. The contribution of American shipyards to victory in World War II cannot be viewed without a mixture of admiration and awe. The flood of ship production made D-Day in Normandy, island hopping in the Pacific, and support to allies such as Britain and the Soviet Union possible. Without the efforts of U.S. shipyards, the outcome of World War II might have been different. The experience of World War I, contrasted with World War II, also suggests building up a neglected industrial base takes precious time that may not be available in the early years of a conflict.

With these historical perspectives in mind, the second major conclusion of this thesis is troubling. That is that this country's ability to build and repair ships is eroding. The trend is evident in the shrinking number of shipyards, skilled workers, and companies capable of supplying component equipment for ships. The causes of this decline are multiple, however, the most compelling reason is largely economic. U.S. shipyards cannot compete effectively with foreign shipyards for private construction or repair business. Low cost labor,

foreign government assistance, technological superiority of overseas shipyards, and lack of U.S. industry initiative are all cited as causes for this phenomenon. To some extent, all of these factors are to blame. Regardless of the cause, the decline of U.S. shipyards impacts directly on this nation's ability to wage prolonged war.

The third conclusion, and answer to the main research question concerns the ability of U.S. shipyards to support full wartime mobilization. Given the projected taskings and resources available, the U.S. shipbuilding and ship repair industry could not support all national defense requirements during a prolonged, global war, usually estimated by defense planners to be of four years duration. A substantial portion of the short-term taskings, including reactivation and battle damage repair could be achieved, but only with close management of skilled manpower resources. However, shortfalls encountered in shipyard capacity, skilled manpower, and component equipment would be crippling to later work, especially the construction of new merchant vessels essential to strategic sealift and the national economy.

This thesis has dealt with a current "snapshot" of the industry; future trends are equally critical to national security. The fourth conclusion is that without new government and industry initiatives, the future is

bleak for American shipyards. With the end of the Reagan Administration naval buildup and concentration of remaining Navy work in selected yards, the industry can be expected to continue to shrink to some lower level of economic equilibrium. In light of its current inadequacy, this future industry will have even less potential to support the national defense.

The fifth and final conclusion is that decisive action is necessary to determine first what constitutes a shipyard base sufficient to meet national security demands and then to move decisively to preserve that base. The actions required may not seem economically advisable in this time of relative peace and constrained federal budgets, but an effective solution to this problem is critical to the planned utilization of other facets of America's defenses.

The U.S. Army's force structure, for example, remains centered on heavy divisions. Furthermore, in any global conflict with the Soviet Union, the majority of these divisions would move from CONUS to a distant theater of operations. With 95 to 99 percent of equipment and supplies for these divisions moving by sea, sealift has been accurately described as the cornerstone of operational warfighting.(1) Therefore, without the ability to reactivate, build, and repair sufficient numbers of ships, the U.S. will see a large portion of its ground force immobilized. In addition, the Navy and

Air Force would require astronomical amounts of fuel and ammunition at far-flung bases in a future global conflict. Only ships are capable of delivering these commodities in such great volume.

Decisive action is clearly required, and there is no shortage of proposals from government and private sources. These proposals span a range of options from a government shipbuilding program to assisting the industry in becoming more competitive in the international market. A review of these recommendations follows.

The President's Commission on Merchant Marine and Defense was established in 1984 to examine the state of America's maritime industries and their national defense potential. This commission, including the U.S. Maritime Administrator, a retired Chief of Naval Operations, and ex-senator Jeremiah Denton, produced several reports during 1987-89, including recommendations for government action. The centerpiece of the commission's plan is a call for the construction of almost 200 militarily useful merchant ships in U.S. shipyards over an 11-year period.(2) This "Procure and Charter Program" would involve federal financing of the construction of the ships. Program cost is estimated to be 13 billion dollars.(3)

Upon completion, ships would be chartered to private ship operators at rates competitive with those available on the world shipping market. Any ships not

immediately chartered would be retained in inactive status by the government for potential national defense use. The commission's analysis indicated both shipyards and shipyard equipment suppliers would require significant increases in employment to complete the construction program. Increased tax revenues resulting from this employment, in addition to charter payments, would defray a significant portion of the government's costs.(4)

The commission also recommended the government move to strengthen existing financial assistance to shipyards, including the Capital Construction Fund, Title XI financing, as well as increasing enforcement of the repair in U.S. requirements of the Tariff Act of 1930. Reviews by the Defense and Commerce Departments on the subject of federal laws and regulations governing shipyards also were advocated. These laws and regulations would be evaluated to identify those that increase shipyard costs or reduce efficiency, with the result being their revision or deletion.(5)

The commission makes a strong case that a healthy merchant construction sector is key to maintaining a viable shipyard mobilization base. Nonetheless, the three commission reports published during the Reagan Administration drew minimal response from the President or Congress. In late February 1989, the final report of the commission, containing status updates on the above

recommendations, was presented to President Bush in a White House meeting. While Commission Director, Allan Cameron, described President Bush as "very receptive in principle"(6) to the report. Given the realities of the federal budget deficit and limited or zero growth in defense spending, however, the outlook for funding this program is bleak. Any attempt to finance this program by cutting spending in other areas of the defense budget also would encounter considerable opposition from the armed services. In light of these considerations, implementation of this program in total is unlikely. Unfortunately, the potential for no action being taken on the recommendations is a real possibility. If this occurs, continued shrinkage of the shipyard industry and resultant loss of national defense potential are virtually assured.

Numerous recommendations for action to improve the health of American shipyards can also be found in the writings of private individuals. These options include:

1. The establishment of a government-financed merchant shipbuilding program, supported by a work force evenly split between experienced workers and trainees drawn from public assistance rolls. Some welfare and unemployment funds would be diverted to pay for this program.(7)

2. Encouraging a more aggressive industry pursuit of foreign Navy construction contracts, aided by

U.S. government action (i.e., linking security assistance to consideration for U.S. shipbuilders).(8)

3. Encouraging more foreign investment in U.S. shipyards, and more joint ventures of the kind that have been undertaken by the U.S. automotive industry.(9)

4. Changing government contracting policy to allow increased consideration of factors other than the lowest bid (i.e., defense mobilization needs) in awarding contracts for Navy work. It is thought this strategy could help preserve what remains of the shipyard base in high-cost areas such as the west coast.(10)

5. Reinstitution of the CDS program along with amendment of the Jones Act to allow U.S. owned, foreign-built, foreign flag vessels to operate in domestic contiguous trade. This would be contingent upon the ship operator agreeing to build under CDS, on a one for one basis, similar ships in U.S. shipyards.(11)

The above recommendations are provided as a broad sampling of current thinking on the shipyard question. In addition to providing more possible topics for research, these ideas provided the foundation on which the following recommendations are based.

If adequate sustainability is to be achieved, several actions should be taken to strengthen the shipyard mobilization base. First, there must be a more aggressive proponency of the fact that industrial preparedness is the basic underpinning of U.S. military

strength. While the Defense Guidance makes strong note of this, more emphasis, both in policy and philosophy, must be placed in this area. In the area of shipyards, a decision on the capacity required for national security should be made, and this base aggressively preserved (or increased).

The statement above is easy to make, but difficult to implement. However, some observations on general strategies are offered. The first tenet of any shipyard assistance program should be to minimize the negative economic impact on the other crucial maritime industry, the U.S. merchant marine. Professor Andrew Gibson of the Naval War College, and former chairman of American Automar Shipping Company, has written extensively on the dangers of forcing private U.S. shipowners to buy expensive American-built ships in order to save U.S. shipyards. This strategy drives shippers away from the U.S. flag and makes their industry, also vital to national security, less competitive internationally. According to professor Gibson:

> ...although the Navy recognizes the need for maintaining a higher shipbuilding base than its future building requirements may sustain, it believes it is the responsibility of others to develop and pay for the necessary program. Since the requirement is clearly one of national defense, it is difficult to understand the reluctance not only to develop the required program, but even to define the size of the base to be maintained.(12)

In light of the security implications for the free world and negative impact of forcing private business into shipyards, shipyard assistance should be federally funded and direct in nature. The "Procure and Charter Program" recommended by the Commission on Merchant Marine and Defense would serve as the keystone of the program. Ships of a simple design would be produced in numbers significant to maintain the shipyard mobilization base deemed prudent in each geographic region of this country. A "domestic content" requirement ensuring increased demand for component equipment would buoy the flagging U.S. supplier industries. There is certainly merit in the idea of instituting a WPA-type jobs training program for shipyard skilled labor; the location of many shipyards might provide an increased source of employment for inner city youths.

This infusion of federal funds should allow U.S. shipyards to make the productivity gains necessary to allow more effective competition with foreign shipyards. Any additional government assistance required should come in the form of CDS, not by requiring U.S. shippers to "buy American" for any routes, foreign or domestic.

The cost of such a program would, of course, be significant. But when placed in perspective, a program of 13 billion dollars over 10 years is, as characterized by Senator Denton, "trivial".(13) To continue to spend

money on armed forces that are increasingly strategically immobile is the real waste.

This government solution is by no means the best answer to America's shipyard requirements. Ideally, a robust, competitive peacetime industry would be standing by today to rapidly convert facilities and manpower to wartime production. Economic realities, however make this an unrealistic expectation. But much U.S. defense policy still rests on just this vision of America as the "arsenal of democracy". Barring radical changes in the role of the U.S. in the world, this country would again be called on to fill that role in defense of ourselves and our allies.

If no action is taken, the decline of the U.S. shipyard industry will continue, with the loss of more jobs, facilities, and national defense capabilities. This continued erosion will present even more daunting obstacles to planners who are only now rediscovering the value of the "operational level of war". The planning and execution of the widely dispersed lengthy campaigns envisioned in this warfare is dependent on sea power for sea control and resupply. Lack of sufficient facilities to reactivate, repair, and build ships may eventually force operational planners to choose between one of several undesirable military options: surrender, withdrawal of committed forces, or use of nuclear weapons to offset enemy numerical superiority.

This outcome would indeed be ironic, for historically, when the national interests of America have been directly threatened, U.S. citizens have responded admirably to the call to fight and produce. In a future conflict endangering this country, there would doubtless be a large pool of citizens willing to sacrifice and do whatever is required to preserve our way of life. But patriotism and enthusiasm will only take them so far. A viable existing industry with a cadre of skilled workers is critical to training and mobilizing this country's greatest wartime asset - its people.

Almost nine years ago, then-presidential candidate Ronald Reagan issued a "Program for the Development of an Effective Maritime Strategy". The statement contained the requirement for a naval-maritime program that would:

> ...Ensure that our vital shipbuilding mobilization base is preserved. It is essential that sufficient naval and commercial shipbuilding be undertaken to maintain the irreplaceable shipbuilding mobilization base. Without this nucleus of trained workers and established production facilities, we can never hope to meet any future challenges to our security.(14)

In the decade since, the potential challenges to security have remained, or increased, while the state of the U.S. shipbuilding and ship repair industry has steadily declined. Our response to this decline in the decade to come may well determine the ability of the U.S.

armed forces to protect this country's security interests.

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APPENDIX A

MAJOR U.S. PRIVATE SHIPBUILDING AND REPAIR FACILITIES

East Coast

Shipbuilding Facilities

Atlantic Marine, Inc. - Fort George Island, FL
Bath Iron Works Corp. - Bath, ME
Bethlehem Steel Corp. - Sparrows Point, MD
General Dynamics Corp. - Electric Boat - Groton, CT
Jacksonville Shipyards (Bellinger) - Jacksonville, FL
Newport News Shipbuilding & Drydock Co. - Newport News, VA
Norfolk Shipbuilding & Drydock Corp. - Norfolk, VA
Pennsylvania Shipbuilding Co. - Chester, PA
Robert E. Derecktor of Rhode Island, Inc. - Middletown, RI

Repair Facilities (With Drydocking)

Bath Iron Works Corp. - Portland, ME
Boston Graving Dock Corp. - East Boston, MA
Boston Marine Industrial Park - Boston, MA
Caddell Drydock & Repair Co. - Staten Island, NY
Colonna's Shipyard Inc. - Norfolk, VA
Detyens Shipyard - Mt. Pleasant, SC
General Ship Corp. - East Boston, MA
Jacksonville Shipyards - Jacksonville, FL
Metro Machine Corp. - Norfolk, VA
New York Shipyard Corp. - Brooklyn, NY
North Florida Shipyards - Jacksonville, FL
Perth Amboy Drydock Co. - Perth Amboy, NJ

Topside Repair Facilities

Associated Naval Architects - Portsmouth, VA
Braswell Shipyards - Charleston, SC
Delta Marine, Inc. - Wilmington, NC
Eastern Technical Enterprises - Virginia Beach, VA
General Ship Repair Corp. - Baltimore, MD
Gowen, Inc. - Portland, ME
JOMAR Corp. of Tidewater - Suffock, VA
Jonathan Corp. - Norfolk, VA
Jonathan Corp. - Virginia Beach, VA
Marine Hydraulics International - Norfolk, VA
Melville Marine Industries - Portsmouth, VA
Metal Trades, Inc. - Hollywood, SC
Moon Engineering - Norfolk, VA
Moon Engineering - Portsmouth, VA
M & W Marine Service, Inc. - Newport News, VA
Newport Offshore, Ltd. - Newport, RI

Promet Marine Services Corp. - E. Providence, RI
Reynolds Shipyard Corp. - Staten Island, Ny
Steel Style, Inc. - Newburgh, NY
Swygert Shipyard, Inc. - St. Johns Island, FL

Gulf Coast

Shipbuilding Facilities

ADDSCO Industries, Inc. - Mobile, AL
American Marine Corp. - New Orleans, LA
Avondale Industries, Inc. - New Orleans, LA
Bethlehem Steel Corp. - Beaumont, TX
Eastern Marine, Inc. - Allanton, FL
Gretna Machine & Iron Works - Harvey, LA
Litton/Ingalls Shipbuilding Division - Pascagoula, MS
Marathon LeTourneau Co. - Brownsville, TX
Moss Point Marine - Escatawpa, MS
Tampa Shipyards, Inc. - Tampa, FL
Todd Shipyards Corp. - Galveston, FL

Repair Facilities (With Drydocking)

Bender Shipbuilding & Repair Co., Inc. - Mobile, AL
Bethlehem Steel Corp.- Sabine - Port Arthur, TX
Bludworth Bond Shipyard - Houston, TX
Gulf Coast Fabrication - Pass Christian, MS
Gulf-Tampa Drydock Co. - Tampa, FL

Topside Repair Facilities

Baker Marine Corp. - Ingleside, TX
Boland Marine Manufacturing - New Orleans, LA
Bollinger Machine Shop & Shipyard - Lockport, LA
Buck Kreihs Co. - New Orleans, LA
Coastal Iron Works - Corpus Christi, TX
Coastal Marine Service of Texas - Corpus Christi, TX
Dixie Machine Welding - New Orleans, LA
Fredeman Shipyard - Sulphur, LA
Gulf Copper & Manufacturing Corporation - Port Arthur, TX
Halter Marine, Inc. - Equitable Division - New Orleans, LA
Hendry Corp. - Tampa, FL
Houston Ship Repair - Houston, Tx
International Ship Repair & Marine Service, Inc. - Tampa, FL
McDermott Shipyard - Morgan City, LA
Newpark Shipbuilding - Houston, TX
Port Allen Marine Service - Port Allen, LA
Textron Marine Systems - New Orleans, LA
Vessel Repair, Inc., - Port Arthur, TX
Violet Dock Port, Inc. - Violet, LA

West Coast

Shipbuilding Facilities

Marine Power & Equipment Yard No. 4 - S. Seattle, WA
National Steel & Shipbuilding Co. - San Diego, CA
Portland Ship Repair Yard - Portland, OR
- Cascade General, Inc.
- Northwest Marine Iron Works
- West State, Inc.

Tacoma Boatbuilding - Tacoma, WA
Todd Pacific Shipyards - Los Angeles, CA
Todd Pacific Shipyards - Seattle, WA

Repair Facilities (With Drydocking)

AK-WA Inc. - Tacoma, WA
Continental Maritime of San Francisco, Inc. - San Francisco, VA
Hunters Point Naval Shipyard - San Francisco, CA
Marine Power & Equipment Yard No. 1 - N. Seattle, WA
Maritime Contractors, Inc. - Bellingham, WA
Pacific Drydock & Repair Co. - Oakland, CA
Southern Oregon Marine - Coos Bay, OR
Southwest Marine, Inc. - San Diego, CA
Southwest Marine, Inc. - Terminal Island, Ca
Southwest Marine of San Francisco - San Francisco, CA
U.S. Naval Station - San Diego, CA
- Pacific Ship Repair
- RMI, Inc.

Topside Repair Facilities

Billfish, Inc. - San Pedro, CA
Campbell Industries - San Diego, CA
Commercial Marine Service, Inc. - Terminal Island, CA
Continental Marine of San Diego - San Diego, CA
Fisherman's Boat Shop - Everett, WA
Foss Shipyard - Seattle, WA
Lake Union Drydock - Seattle, WA
Larson Boat Shop - Terminal Island, CA
Pacific Fisherman, Inc. - Seattle, WA
Service Engineering Company - San Francisco, CA

Great Lakes

Shipbuildling Facilities

Bay Shipbuilding Corp. - Sturgeon Bay, WI
Peterson Builders - Sturgeon Bay, WI
Fraser Shipyards - Superior, WI
The Toledo Shipyard - Toledo, OH

Repair Facilities (With Drydocking)

None

Topside Repair Facilities

G & W Industries, Inc. - Cleveland, OH
H. Hanson Industries - Toledo, OH
Marinette Marine Corp. - Marinette, WI
Nicholson Terminal & Dock Co. - River Rouge, MI
R. J. Rotunda, Inc. - Ontonagon, MI

Non-Conus

Shipbuilding Facilities

None

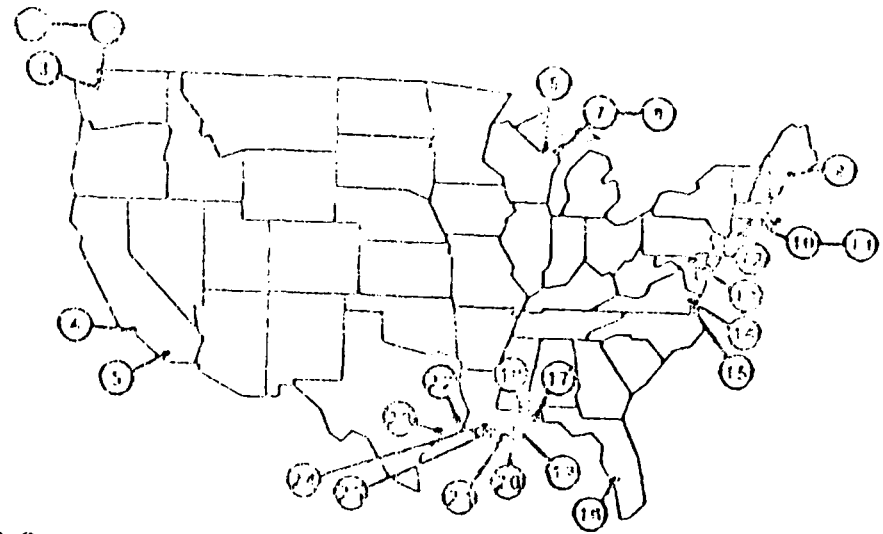
Repair Facilities (With Drydocking)

Honolulu Shipyard, Inc. - Honolulu, HI
Ketchikan Shipyard, Inc. - Ketchikan, AK
MARISCO, Ltd. - Honolulu, HI
Puerto Rico Drydock & Marine Terminals - San Juan, PR

Topside Repair Facilities

None

ACTIVE U.S. SHIPBUILDING BASE

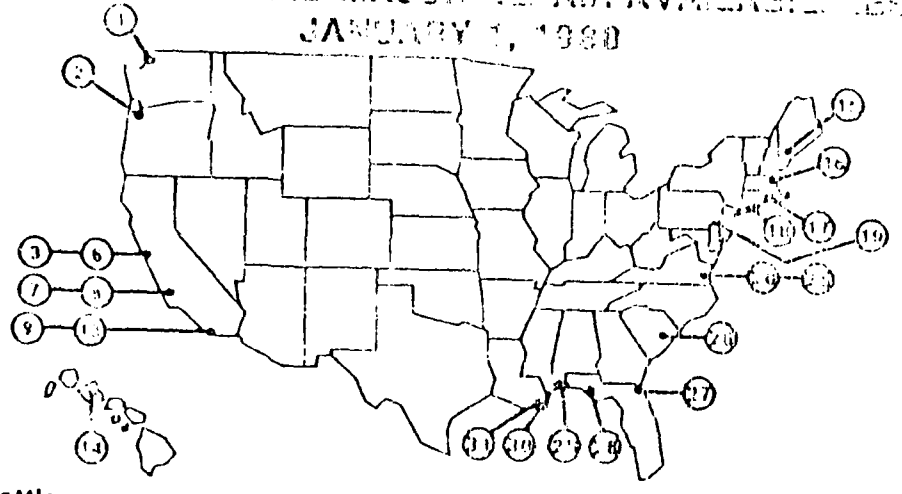


1. Todd-Seattle
2. [illegible]
3. Tacoma Boat
4. Todd-Los Angeles
5. National Steel
6. Marinette
7. Bay SB Corporation
8. Peterson

*Closed in 1988.

9. Bath Iron Works
10. B E Derecktor
11. GD-Electric Boat
12. Penn Ship
13. Bath-Sparrows Point
14. Newport News
15. Norfolk SB & DD
16. Tampa Ship
17. ADDSCO Industries
18. Litton-Ingalls
19. Avondale Shipyards
20. McDermott
21. Halter
22. Bath-Beaumont
23. Todd-Galveston
24. Textron
25. Moss Point Marine

PRIVATE SHIPYARDS HOLDING CONTRACTS FOR NAVY OVERHAULS AND MAJOR REPAIR AVAILABILITIES JANUARY 1, 1980



1. Todd, Seattle
2. Northwest Marine
3. Pacific Drydock
4. Continental Maritime, SF
5. Service Engineering
6. Southwest Marine, SF
7. Southwest Marine, SP
8. Todd, San Pedro
9. National Steel
10. Campbell Industries
11. Arcwel Corp.
12. Continental Maritime, SD
13. Southwest Marine, SD
14. Honolulu Shipyard
15. Bath Iron Works
16. General Ship
17. Robert E. Derecktor
18. G. Marine Diesel
19. Penn Ship
20. Jonathan Corp.
21. Moon Engineering
22. Norfolk Shipbuilding
23. Metro Machine
24. Newport News
25. Marine Hydraulics
26. Defyens Shipyards
27. Atlantic Drydock
28. Runyan Machine
29. ADDSCO Industries
30. Ingalls Shipbuilding
31. Avondale Industries

APPENDIX D

DESCRIPTION OF SHIPYARD SKILLED TRADES

Electronic Technician - Installs and repairs ship electronic systems including radars, communications equipment, and weapons systems.

Inspector - Performs surveys of shipyard work assignments and quality assurance inspections of completed work.

Insulator - Installs insulation material on piping, machinery, and structural members within the hull and superstructure of a ship.

Loftworker - Lays out to scale the lines of a ship preparatory to the making of blueprints and tools.

Machine-Tool Operator - Machines, cuts and grinds component equipment such as gears and shafts to close tolerances using specialized machine tools including lathes, planers, mills, and shapers.

Machinist - Installs ship machinery such as propelling machinery, motors, and pumps; tests and inspects installed machinery.

Marine Electrician - Installs and repairs wiring, fixtures, and equipment for all electrical services aboard ship and in shipyard facilities.

Marine Pipefitter - Lays out, installs, and maintains ships' piping systems, such as steam heat and power, hot water, hydraulic, air pressure and oil lines.

Marine Rigger - Installs and repairs rigging and weight-handling gear on ships and attaches hoists and pulling gear to rigging to lift, move, and position machinery, equipment, structural parts, and other heavy loads aboard ship.

Painter - Prepares, inspects, primes and finishes wood, plastic, metal parts, equipment and surfaces on all types of ships, boats, buildings and other structures, to prevent corrosion and electrolysis, with a protective film or decorative paint.

Sheetmetal Worker - Performs routine layout and pattern work on sheetmetal articles and equipment in conjunction with forming, fabricating, assembling, installing, and repairing of various sheetmetal items.

Shipfitter - Lays out and fabricates metal structural parts, such as plates, bulkheads, and frames, and braces them in position within the hull of ship for riveting or welding.

Shipwright - Shapes, finishes, and installs wooden spars, masts, and wood framing in ship. Builds keel and bilgeblocks, cradles, and shoring for supporting ships in drydock, marine railways, shipways, or building docks, using power and hand woodworking tools.

Welder - Welds metal parts together, using gas welding or arc welding processes. Performs related tasks, such as flame cutting and grinding. May repair broken or cracked parts, fill holes, and increase size of metal parts.

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Personnel Requirements for an Advanced Shipyard Technology, 1980, p. 125.

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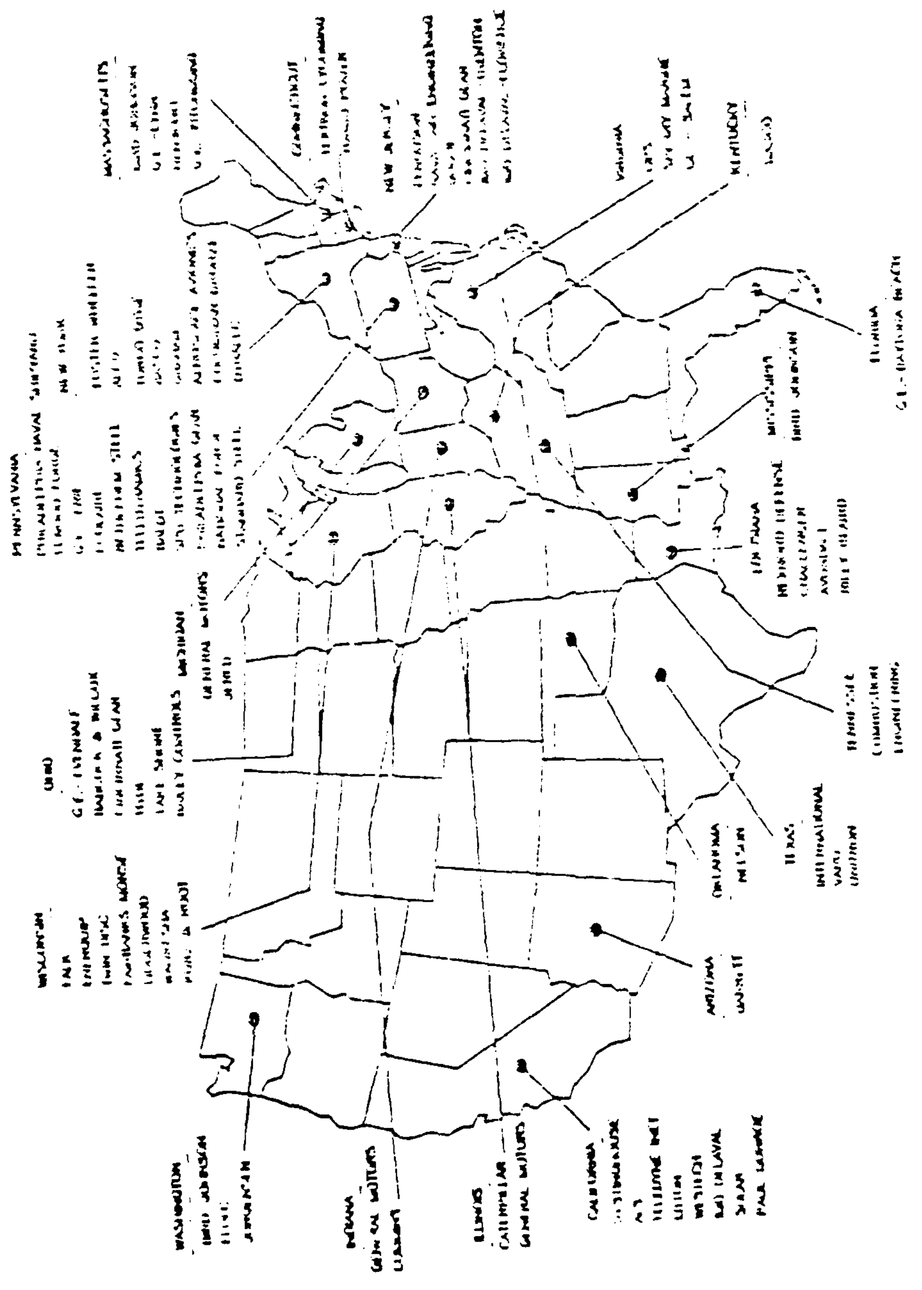
APPENDIX E



KEY SHIP SYSTEMS MANUFACTURERS

APPENDIX F

READY RESERVE FORCE SHIPS

Vessel	Assigned Location	RRF Status	Ship Mgr	Agent Operator
Cape Alexander	Jacksonville	5	Marine Car	N. Florida Syd
Cape Ann	Quonset Pt	5	AMSEA	Derecktor
Cape Archway	Baltimore	5	Marine Car	Bethlehem Sp Pt
Cape Avinof	Quonset Pt	5	AMSEA	Derecktor
Cape Canaveral	Portland	5	AMSEA	Bath IW
Cape Canso	Norfolk	5	Marine Car	Moon
Cape Decision	Baltimore	5	MTL	Bethlehem Sp Pt
Cape Diamond	Brooklyn	5	MTL	Universal Marine/Bklyn
Cape Domingo	Brooklyn	5	MTL	Olympic Brooklyn
Cape Douglas	Jacksonville	5	MTL	N. Florida Syd
Gopher State	Cheatham Annex	5	IUM	Metro/Cheatham Annex
Patriot State	Buzzards Bay	5	TSN	Ind Weld/Buzzards Bay
Ambassador	Cheatham Annex	10	Marine Car	Metro/Cheatham Annex
Cape Carthage	Melville	5	AMSEA	Bath IW
Cape Catoche	Providence	5	AMSEA	General Ship
Lake	Philadelphia NSY	5	AMSEA	Penn/Puerto Rico Ship Repair
Pride	Philadelphia NSY	5	AMSEA	New York Ship/Brooklyn
Stan	Philadelphia NSY	5	AMSEA	Pennsylvania Ship [illegible]
Southern Cross	Philadelphia NSY	5	AMSEA	Philly Ship
Nile	Quonset Pt	10	AMSEA	Newport Offshore
Chesapeake State	James River	5	IUM (T)	Moon
Cape Johnson	James River	5	In Foreign	Newport News
Patchertail State	James River	5	IUM (T)	Olympic Portsmouth
Cape Henry	James River	5	IUM	Moon/Portsmouth
Cape Hudson	James River	5	IUM	Moon/Portsmouth
Cape Lambert	James River	5	MTL (T)	Metro
Cape Nome	James River	5	IUM (T)	[illegible]
Cape Lobos	James River	5	MTL (T)	Metro
Cape Mohican	James River	5	IUM	Moon
Agent	James River	5	Marine Car	Gibbons's
Cape Alava	James River	5	Marine Car	[illegible]
Keystone State	James River	5	IUM	Olympic/Portsmouth
Cape Duby	James River	5	In Foreign	[illegible]
Adventurer	James River	10	Marine Car	Jonathan
Banner	James River	10	Marine Car	[illegible]
Courier	James River	10	Marine Car	[illegible]
ADM W. Callaghan	James River	10	Marine Car	Jonathan
Cape San	San Pedro	5	IUM	Todd San Pedro
Cape Strida	Richmond	5	AFL	Continental
Cape Boyer	Richmond	5	AFL	S. W. Marine
Cape Breton	San Francisco	5	MTL	General Eng Portland
Cape Ducato	San Pedro	5	IUM	Todd San Pedro
Gem State	Tacoma	5	IUM (T)	Tacoma Boat
Cheir	San Pedro	5	IUM	Todd San Pedro
Northern Light	Portland	5	AFL	N. W. Marine
Austral Lightning	San Francisco	5	IUM	Triple A
California	Alameda	5	AFL	General Eng Portland

Vessel	Assigned Location	RRF Status	Ship Mgr	Assn Contractor
Cape Blanco	Tacoma	5	APL	Todd
Cape Edmont	Portland	5	ICM	Cascade
Cape Isabel	Portland	5	APL	N. W. Marine
Comet	Portland	5	APL	West State
Grand Canyon State	Portland	5	ICM (T)	West State
Jupiter	Tacoma	5	APL	Todd
Cape Horn	Hunters Pt	5	ICM	Service Eng
Alaska	Yokohama	10	Crowley	Ishikawajima Hago
Chattahoochee	Yokohama	10	Crowley	Ishikawajima Hago
Midway	Pearl Harbor	10	Crowley	Marisco
Cape Gibson	Suisun Bay	5	APL (T)	Triple A
Cape Girardeau	Suisun Bay	5	APL (T)	J & P Marine, Inc.
Shiphone	Suisun Bay	10	APL	Pacific SB Oakland
Cape Farewell	Mobile	5	IMC	Buck Kriehs
Cape Flattery	Mobile	5	IMC	Buck Kriehs
Cape Florida	Mobile	5	IMC	Berger
Buyer	Mobile	5	CMI (T)	Berger
Cape Inscription	Violet	5	Lykes (T)	Boland
Cape May	Violet	5	CMI	Avondale
Cape Mendocino	Violet	5	CMI	Dixie Mach
American Osprey	Beaumont	10	Am For ign	Todd
Del Viento	Beaumont	5	PMC	MCC Fabrication
Gulf Shipper	Beaumont	5	ALLMARSVC	Coastal Marine
Mission Buenaventura	Beaumont	5	MCL (T)	Gulf Shipper
Mission Capistrano	Beaumont	5	MCL (T)	Gulf Shipper
Del Monte	Beaumont	5	PMC	Vessel Repair
Gulf Trader	Beaumont	5	ALLMARSVC	Coastal Marine
Potomac	Beaumont	5	Am Foreign	Coastal Marine
Gulf Farmer	Beaumont	10	ALLMARSVC	Ingalls
American Explorer	Beaumont	10	Am Foreign	Avondale
Cape Chalmers	Beaumont	10	CMI	Avondale
Cape Cod	Beaumont	10	CMI	Buck Kriehs
Santa Ana	Beaumont	10	CMI	Galveston SY
Maine	Beaumont	10	Am Foreign	Berger
Pioneer Commander	Beaumont	10	PMC	Todd
Pioneer Contractor	Beaumont	10	PMC	Todd
Washington	Beaumont	10	Am Foreign	Berger
Cape Catawba	Beaumont	10	Am Foreign, T	MCC Fabrication
Cape Clear	Beaumont	10	CMI	Dixie Mach
Gulf Banker	Beaumont	10	ALLMARSVC	Ingalls
Gulf Merchant	Beaumont	10	ALLMARSVC	Ingalls
Cape Charles	Beaumont	10	CMI	Avondale
Del Valle	Beaumont	10	PMC	Galveston SY
Pioneer Crusader	Beaumont	10	PMC	Todd

Legend - General Agents/Ship Managers

ALLMARSVC - All Marine Services, Ltd
Am Foreign - American Foreign Shipping Co., Inc.
AMSEA - American Overseas Marine
APL - American President Lines, Ltd.

Legend - General Agents/Ship Managers

Crowley - Crowley Maritime Corporation
IMC - International Marine Carriers, Inc.
IOM - Interocean Management Corporation
Lykes - Lykes Bros. Steamship Co.
Marine Car - Marine Carriers (USA) Inc.
MTL - Marine Transport Lines, Inc.
OMI - OMI Corporation
P&O - P&O Engineering, Inc.
TBN - To Be Named
(T) - Temporary

Source: U.S. Maritime Administration, Ships of the National Defense Reserve Fleet by Category, 1988.

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